RADIO TRANSMITTING TUBES

Radio Transmitting Tubes

The first publication in this book, ET-5—Radio Transmitting Tubes, lists all G-E transmitting tubes, essential technical data, and list prices.

Technical Descriptive Bulletins (GET) are filed in the first section of this book numerically by tube type number. Installation and Operation Instructions (GEH) are filed in the secondary section by publication number and an index to the instructions is provided. A copy of the standard Service Report used with General Electric tubes is included as the last publication in the second section.

Although the information is listed in loose-leaf form to facilitate revisions and additions, the General Electric Company reserves the right to change prices or other data without notice.

The book is recorded in your name as follows:

Name Radio Officer John S. Baker

Address S.S. George Verity, U.S. Lines

c/o Postmaster

New York, New York

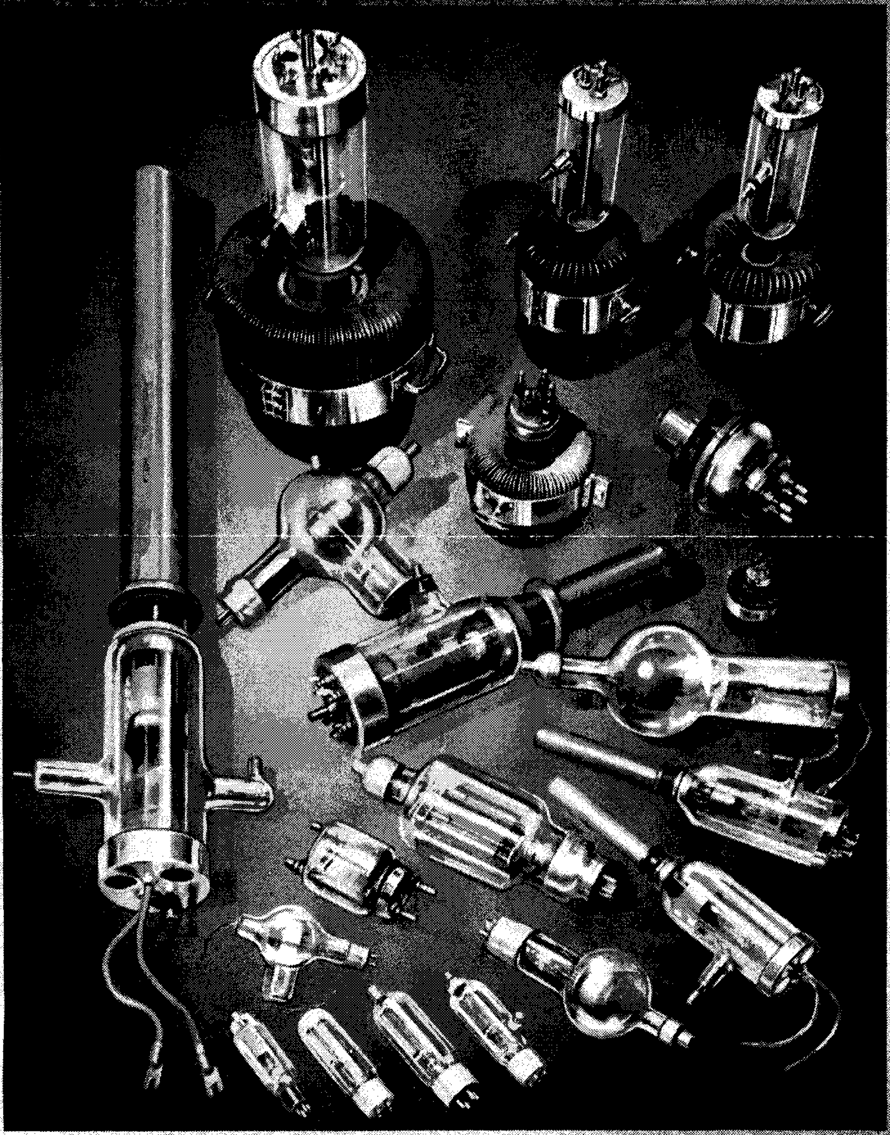
List E-201

GENERAL ELECTRIC

Schenectady, N. Y.

GENERAL ELECTRIC

Electronic Tubes for Radio Application



G-E Electronic Firsts

- Thoriated tungsten filaments
- High power water cooled tubes
- The screen grid tube
- Hot cathode, mercury vapor rectifiers
- Metal tubes for receivers
- Introverted anode for wide band television
- Small size vacuum capacitors
- Flexible diaphragm vacuum switches

These and many other G-E firsts combine with careful workmanship, exacting construction and rigid testing to provide you the finest in electronic tubes.

G.E. offers you a complete [illegible] varying from tiny tubes [illegible] high up to giant radio [illegible] tubes five feet high. [illegible] tube for every [illegible]

Let G-E electronic engineers help select the proper tube for your application.
For operating dependability, for long life, for maximum economy, [illegible] tubes. Y[illegible] [illegible]

Prices Effective Dec. 1, 1944

Electronic Tubes for Radio Applications

HIGH-VACUUM TYPES

Type No.	Users' Price	No. of Electrodes	CATHODE Volts	CATHODE Amp.	PLATE Max. Volts	PLATE Max. Amp.	PLATE Max. Input, Watts	PLATE Max. Dissipation, Watts	MAX. FREQ. MC. @ Max. Plate Input	MAX. FREQ. MC. @50% Max. Plate Input	Mu	Gm	Bulletin No.
GL-146	$15.00	3	10	3.25	1500	0.200	300	125	15	60	75	....	ET-T81
GL-152	15.00	3	10	3.25	1500	0.200	300	125	15	60	25	....	ET-T11
GL-159	60.00	3	10	9.60	2000	0.400	800	250	15	35	20	....	GET-739
GL-169	60.00	3	10	9.60	2000	0.400	800	250	15	35	85	....	ET-T108
GL-203-A	10.00	3	10	3.25	1250	0.175	220	100	15	80	25	....	GET-501
GL-204-A	85.00	3	11	3.85	2500	0.275	690	250	3	30	23	....	GET-502
GL-211	10.00	3	10	3.25	1250	0.175	220	100	15	80	12	....	GET-503
GL-242-C	12.00	3	10	3.25	1250	0.150	188	100	6	30	12.5	....	GET-956
GL-276-A	12.00	3	10	3.0	1250	0.125	156	100	20	100	12	....	GET-955
GL-800	10.00	3	7.5	3.25	1250	0.080	100	35	60	180 @ 55%	15	....	ET-T59
GL-801-A	2.50	3	7.5	1.25	600	0.070	42	20	60	120	8	....	GET-761
GL-802	3.50	5	6.3*	0.90	500	0.060	25	10	30	100 @ 55%	....	2250	ET-T57
					600	**0.060**	**33**	**13**					
GL-803	25.00	5	10	5.00	2000	0.175	350	125	20	70	....	4000	GET-759
GL-805	10.00	3	10	3.25	1500	0.210	315	125	30	80	....	....	GET-921
GL-806	22.00	3	5	10.0	3000	0.200	600	150	30	100	12.6	....	ET-T72
					3300	**0.300**	**1000**	**225**					
GL-807	2.25	5	6.3*	0.90	600	0.100	60	25	60	125 @ 55%	....	6000	ET-T38
					750	**0.100**	**75**	**30**					
GL-809	2.50	3	6.3	2.50	750	0.100	75	25	60	120	50	....	ET-T58
					1000	**0.100**	**100**	**30**					
GL-810	13.50	3	10.0	4.50	2000	0.250	500	125	30	100	36	....	ET-T99
					2250	**0.275**	**620**	**150**					
GL-811	3.50	3	6.3	4.00	1250	0.125	155	40	60	115	160	....	GET-754
					1500	**0.150**	**255**	**55**					
GL-812	3.50	3	6.3	4.00	1250	0.125	155	40	60	100 @ 60%	29	....	ET-T71
					1500	**0.150**	**225**	**55**					
GL-813	22.00	4	10.0	5.00	2000	0.180	360	100	30	60 @ 75%	....	3750	ET-T1
GL-814	15.50	4	10.0	3.25	1250	0.150	180	50	30	100	....	3300	ET-T22
					1500	**0.150**	**225**	**65**					
GL-815	4.50	5†	6.3†	0.8†	400	0.150	60	20	150	225 @ 70%	6.5	4000	ET-T4
					500	**0.150**	**75**	**25**					
GL-828	17.50	5	10.0	3.25	1250	0.160	200	70	30	75 @ 65%	....	4500	GET-986
					1500	**0.180**	**270**	**80**					
GL-829-B	19.50	5†	6.3†	1.125†	750	0.240	120	40	200	250 @ 89%	....	8500	GET-965
GL-830-B	10.00	3	10.0	2.0	1000	0.150	150	60	15	60 @ 54%	25	....	ET-T20
GL-833-A	76.50	3	10.0	10.0	4000	0.500	1800	400	30	75 @ 72%	35	....	ET-T3
					4000	**0.500**	**2000**	**450**					
GL-835	10.00	3	10.0	3.25	1250	0.175	220	100	20	100	12	3600	ET-T63
GL-837	2.80	5	12.6*	0.70	500	0.080	32	12	20	80	....	3400	GET-750
GL-838	9.00	3	10.0	3.25	1250	0.175	220	100	30	120	....	....	GET-920
GL-842	3.25	3	7.5	1.25	425	0.028	....	12	....	....	3	....	ET-T13
GL-843	1.65	3	2.5*	2.50	450	0.040	....	15	6	30 @ 80%	7.7	....	GET-751
GL-845	10.00	3	10.0	3.25	1250	0.175	....	75	....	....	5	....	GET-505
GL-849	120.00	3	11.0	5.00	2500	0.350	875	400	3	30	19	....	GET-489
GL-851	160.00	3	11.0	15.50	2500	1.00	2500	750	3	15	20.5	....	ET-T41
GL-860	32.50	4	10.0	3.25	3000	0.150	300	100	30	120	200	1100	ET-T39
GL-861	155.00	4	11.0	10.0	3500	0.350	1200	400	20	60	300	2400	ET-T5
GL-1613	1.80	5	6.3*	0.70	350	0.050	17.5	10	45	90 @ 85%	....	2500	ET-T70
GL-1614	2.80	5	6.3*	0.90	375	0.110	35	21	80	120 @ 75%	....	6050	GET-769
GL-1619	2.20	4	2.5	2.0	400	0.075	30	15	45	90 @ 77%	....	4500	GET-904
GL-1623	2.50	3	6.3	2.5	750	0.100	75	25	60	115	20	....	GET-748
					1000	**0.100**	**100**	**30**					
GL-8012	19.00	3	6.3	2.0	1000	0.080	50	40	500	600 @ 63%φ	18	....	ET-T67

Figures in bold type are ICAS ratings.

* Heater-type cathode.

† Per section.

‡ Single- or two-phase filament. Voltage is per unit.

§ Single-, three-, or six-phase filament. Voltage is per strand, current is per terminal.

†† Single- or three-phase filament. Voltage is per strand, current is per strand.

¶ Quadrature operation.

△ Surge-limiting diode operation.

φ Maximum permissible percentage of only maximum plate voltage, the minimum plate input may be 100 per cent of its rated value.

Prices and other data subject to change without notice

HIGH-VACUUM, AIR-COOLED TYPES

Type No.	Users' Price	Users' Renewal Price ***	No. of Electrodes	CATHODE Volts	CATHODE Amp	PLATE Max. Volts	PLATE Max. Amp	PLATE Max. Plate Input, Watts	PLATE Max. Dissipation, Watts	MAX. FREQ. MC. @Max. Plate Input	MAX. FREQ. MC. @50% Max. Plate Input	Mu	Bulletin No.
GL-3C22	$60.00	......	3	6.3	2.0	1000	0.150	150	125	1000	....	40	
GL-833-A	76.50	......	3	10	10	4000	0.500	1800	400	20	75@65%	35	ET-T3
						4000	**0.500**	**2000**	**450**				
GL-889-R	325.00	$295.00	3	11	125	8500	2.00	16000	5000	25	....	21	ET-T120
GL-891-R	410.00	310.00	3	11‡	60.0	10000	2.00	15000	4000	1.6	20	8	ET-T40
GL-892-R	410.00	310.00	3	11‡	60.0	12500	2.00	18000	4000	1.6	20	50	ET-T36
GL-893A-R	800.00	650.00	3	10§	61.0§	20000	4.00	70000	20000	5	25	36	GET-959
GL-895-R	1250.00	1050.00	3	19 #	138	17000	9.00	110000	20000	6	....	37	....
GL-8002-R	125.00	......	3	16	38.0	3500	1.00	3000	1200	120	200	20.5	ET-T16
GL-8010A-R	55.00	......	3	5.7*	2.0	1100	0.100	....	50	350	....	30	GET-980

HIGH-VACUUM, WATER-COOLED TYPES

Type No.	Users' Price	Users' Renewal Price ***	No. of Electrodes	CATHODE Volts	CATHODE Amp	PLATE Max. Volts	PLATE Max. Amp	PLATE Max. Plate Input, Watts	PLATE Max. Dissipation, Watts	MAX. FREQ. MC. @Max. Plate Input	MAX. FREQ. MC. @50% Max. Plate Input	Mu	Bulletin No.
GL-207	$220.00	......	3	22	51.0	15000	2.00	30000	10000	1.5	20	20	ET-T49
GL-846	200.00	......	3	11	51.0	7500	1.00	7500	2500	50	150	40	GET-603
GL-858	275.00	......	3	22	52.0	20000	2.00	40000	20000	1.5	40	42	ET-T25
GL-862-A**	750.00	......	3	33	207.0	20000	10.00	200000	100000	1.6	....	48	ET-T50
GL-880	350.00	......	3	12.6	320.0	10500	6.0	60000	20000	25	100	20	ET-T128
GL-889	175.00	......	3	11	125	8500	2.00	16000	5000	50	150	21	ET-T18
GL-891	285.00	......	3	11‡	60.0	12000	2.00	18000	6000	1.6	20	8	ET-T9
GL-892	190.00	......	3	11‡	60.0	15000	2.00	30000	10000	1.6	20	50	ET-T110
GL-893-A	450.00	......	3	10§	61.0§	20000	4.00	70000	20000	5	40	36	ET-T69
GL-895	950.00	......	3	19 #	138	17000	9	140000	40000	6	....	37	....
GL-898-A**	750.00	......	3	16.5††	70.0††	20000	10.00	200000	100000	1.6	....	45	ET-T109
GL-8002	110.00	......	3	16	38	3500	1.00	3000	1200	150	300	20.5	ET-T15
GL-8009	450.00	......	3	12.6	320	10500	6.00	60000	20000	25	100	20	ET-T14

MERCURY-VAPOR RECTIFIERS

Type No.	Users' Price	No. of Electrodes	CATHODE Volts	CATHODE Amp	Max. Peak Inverse Volts	Avg. Plate Amp.	Bulletin No.
GL-266-B	$160.00	2	5	30	22000	5.0	GET-745
						10.0¶	
GL-816	1.00	2	2.5	2.0	5000	0.125	ET-T10
GL-857-B	160.00	2	5	30	22000	5.0	GET-745
						10.0¶	
GL-866-A/866	1.50	2	2.5	5	10000	0.25	ET-T103
GL-869-B	100.00	2	5	18.0	20000	2.5	GET-964
					15000¶	5.0¶	
GL-870-A	600.00	2	5	65.0	16000	75.0	ET-T17
GL-872-A/872	7.50	2	5	7.5	10000	1.25	ET-T12

GASKETS FOR WATER-COOLED TYPES

Cat. No.	Used On Tube Type	Users' Prices
5182028P1	GL-862-A, GL-880, GL-898-A	$0.98
5182028P2	GL-858, GL-893-A	.80
5182028P3	GL-214, GL-846, GL-207, GL-891, GL-892	.17
5182028P8	GL-889	.35
5182028P10	GL-8002	.17

THYRATRONS—grid-controlled gaseous discharge tubes

Type No.	Users' Price	No. of Electrodes	CATHODE Volts	CATHODE Amp	PLATE Peak Inv. Volts	PLATE Peak Amp	PLATE Avg Amp	Starting Grid Voltage	Temp Range Condensed Mercury C	Shipping Weight in Lb	Bulletin No.
GL-3C23	$9.00	3	2.5	7.0	1250	6.0	1.5	Neg	+40 – +80	3	ET-T62
FG-17	6.00	3	2.5	5.0	5000	2.0	0.5	Neg	—40 – +80	4	GET-428
GL-502	1.50	4	6.3	0.6	1300	0.500	0.100	Neg	—40 – +80(‖)	3	GET-1079

HIGH-VACUUM RECTIFIERS

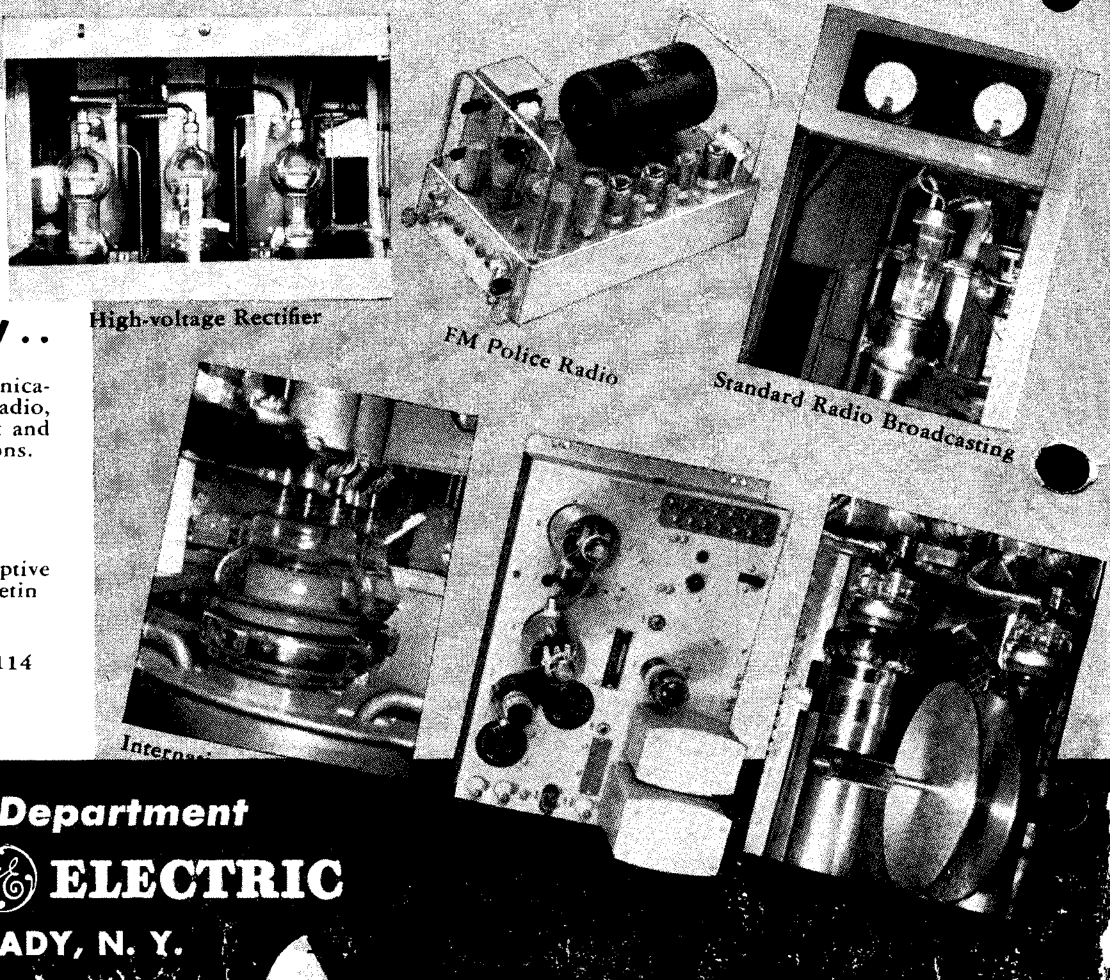
Type No.	Users' Price	No. of Electrodes	CATHODE Volts	CATHODE Amp.	PLATE Max. Inv. Volts	PLATE Max. Amp.	PLATE Average Amp.	Voltage Drop Volts	Average Dissipation Watts				Bulletin No.
GL-217-C	$20.00	2	10	3.25	7500	0.600	....	210	....	....	....	....	GET-762
GL-836	11.50	2	2.5	5.0	5000	1.0	0.25	45	....	....	....	....	GET-972
GL-1616	5.75	2	2.5	5.0	5500	0.800	0.13	75	....	....	....	....	GET-976
GL-1641	3.75	3	5.0	3.0	2120	0.250	....	61	....	....	....	....	GET-987
GL-8013-A	12.00	2	2.5	5.0	40000	0.150	0.020	....	....	....	....	....	ET-T11
GL-8020	18.00	2	5.0	6.0	40000	0.750	0.100	200	....	....	....	....	GET-988
			5.8△	....	12500△	....	....	....	75△	....	....	....	

Figures in bold type are ICAS ratings.
* Heater-type cathode.
*** Applies when a radiator in good condition is returned prepaid to Schenectady.
** Credit for return, prepaid, to Schenectady—carton $5.00, tube $10.00.
‡ Single- or two-phase filament. Voltage is per unit.
§ Single-, three-, or six-phase filament. Voltage is per strand, current is per terminal.
†† Single- or three-phase filament. Voltage is per strand, current is per strand.
¶ Quadrature operation. △Surge-limiting diode operation.
(‖) Ambient temperature range.
Voltage to neutral.

File No. 8850 12-44 (15M)

FOR RADIO APPLICATION

G-E



High-voltage Rectifier

FM Police Radio

Standard Radio Broadcasting

G-E

Electronic tubes are at work today . .

in all types of government communications, FM, television, police radio, carrier current, standard broadcast and all kinds of special radio applications.

also look to G-E for

	Descriptive Bulletin
Electronic Tubes for Industry	ETI-12
Electronic Receiving Tubes	MAQ-114
Vacuum Switches	ETX-1
Vacuum Capacitors	ETX-2

Electronics Department

GENERAL ELECTRIC

SCHENECTADY, N. Y.

G-E TRANSMITTING TUBES
INTERCHANGEABILITY CHART

Other Types	G-E Equivalent	Other Types	G-E Equivalent	Other Types	G-E Equivalent	Other Types	G-E Equivalent
BW-11	GL-834	211C	GL-835	WE-357A	* GL-833A	857A	GL-857B
RK-11	* GL-1623	211D	FP-285	358-A	GL-858	857B	GL-857B
RK-12	* GL-809	217C	GL-217C	361A	* GL-835	858	GL-858
HV-18	* FP-252A	218	GL-218	369A	GL-869B	860	GL-860
T-20	GL-1623	218S	* GL-218	376A	GL-276A	861	GL-861
TZ-20	* GL-809	219	GL-219	384D	* GL-845	862	GL-862
RK-21	* GL-838	241B	* GL-849	450T	* GL-833A	863	* GL-892
RK-23	* GL-802	242-A-B-C	GL-242C	450-TH	* GL-833A	865	GL-865
RK-23A	* GL-802	249B	* GL-866A/866	450-TL	* GL-833A	866	GL-866A/866
HY-25	* GL-809	250TH	* GL-806	WL-460	FP-252A	866A	GL-866A/866
RK-25	GL-802	250TL	GL-806	WL-463	* GL-806	866A/866	GL-866A/866
RK-25B	GL-802	251A	* GL-851	WL-469	* GL-211	866B	* GL-866A/866
RK-28A	GL-803	254B	* GL-865	WL-469	FP-285	869A-B	GL-869B
RK-30	GL-800	255B	* GL-869B	520B	GL-520B	870	GL-870
RK-32	* GL-834	258B	* GL-866A/866	WL-531	* GL-218	870A	GL-870A
35-T	* GL-812	260A	GL-860	HK-654	* GL-833A	872	GL-872
RK-36	* GL-806	261A	* GL-835	T-756	* GL-1623	872A	GL-872A
RK-39	GL-807	266B	GL-866B	800	GL-800	880	GL-880
HY-40	* GL-802	266C	GL-857B	801	GL-801	WL-881	* GL-869B
T-40	* GL-812	267B	* GL-872A	801A	GL-801	889	GL-889
HY-40Z	* GL-809	270A	* GL-849	802	GL-802	889R	GL-889R
TZ-40	* GL-811	276A	GL-276A	803	GL-803	891	GL-891
RK-41	* GL-807	279A	* GL-851	805	GL-805	891R	GL-891R
RK-44	GL-837	284D	* GL-845	T-805	GL-805	892	GL-892
RK-45	* GL-837	295A	GL-203A	806	GL-806	892R	GL-892R
RK-47	GL-814	298A	* GL-862	807	GL-807	893	GL-893
RK-48	* GL-813	303A	GL-203A	809	GL-809	893R	GL-893R
RK-49	* GL-807	304A	GL-204A	810	GL-810	898	GL-898
UH-50	* GL-837	304B	GL-834	811	GL-811	905	GL-805
HY-51Z	* GL-811	F-307A	GL-207	812	GL-812	938	GL-838
RK-52	* GL-811	310	* GL-801	813	GL-813	941	PT-841
RK-57	GL-805	311	GL-211	814	GL-814	945	GL-845
RK-58	GL-838	311CT	GL-835	815	GL-815	949	GL-849
RK-60	GL-1641	311T	GL-211	T-825	* GL-1623	951	GL-851
HY-61	* GL-807	311T	FP-285	829	GL-829	966	GL-866A/866
RK-63	* GL-806	317C	GL-217C	833	GL-833A	966A	GL-866A/866
HY-69	* GL-807	318A	GL-218	833A	GL-833A	972	GL-872
HF-100	* GL-810	F-319A	GL-219	834	GL-834	972A	GL-872A
ZB-120	* GL-838	WE-319A	GL-872A	835	GL-835	1613	GL-1613
T-125	* GL-810	WE-322A	GL-803	836	GL-836	1614	GL-1614
TW-150	* GL-806	331A	GL-805	837	GL-837	1616	GL-1616
TW-150	* GL-810	332A	* GL-803	838	GL-838	1619	GL-1619
HF-200	FP-252A	341AA	GL-891R	841	PT-841	1623	GL-1623
HF-200	* GL-810	342B-C	GL-242C	843	GL-843	1625	* GL-807
203A	GL-203A	F-346A	GL-846	845	GL-845	1627	* GL-810
203Z	* GL-838	350A	* GL-807	846	GL-846	1628	* GL-8012
204A	GL-204A	F-353A	GL-872A	848	* GL-891	8002	GL-8002
207	GL-207	HK-354	* GL-806	849	GL-849	8002R	GL-8002R
211	GL-211	F-357A	GL-857B	851	GL-851	8012	GL-8012

* *Approximately equivalent; has similar ratings but is not completely interchangeable.*

FOR FURTHER INFORMATION on G-E electronic tubes, ask for Bulletins GEA-3315C and GEA-3736 containing data and prices. For information on specific types, please ask for technical information sheets by tube type numbers. Any G-E tube distributor, or G-E sales office can supply this information. Or write direct to General Electric, Radio and Television Department, Schenectady, N. Y.

Supersedes issue dated Sept. 8, 1941.

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

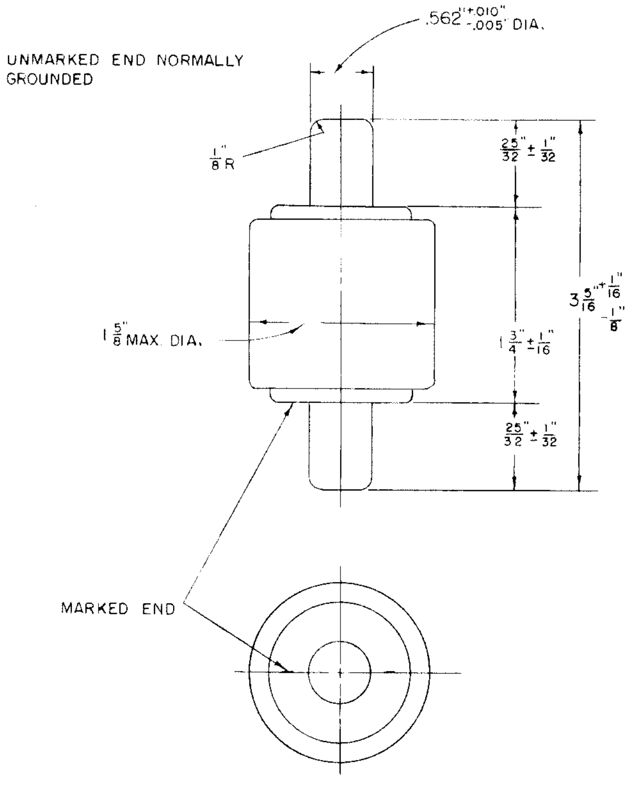
Vacuum Capacitors GL-1L21, GL-1L33, GL-1L36 and GL-1L38--Description and Rating

These vacuum capacitors are designed for circuits where the peak voltage is 7500 volts. Among the advantages of these capacitors is their small size which permits a more compact design than that of air capacitors.

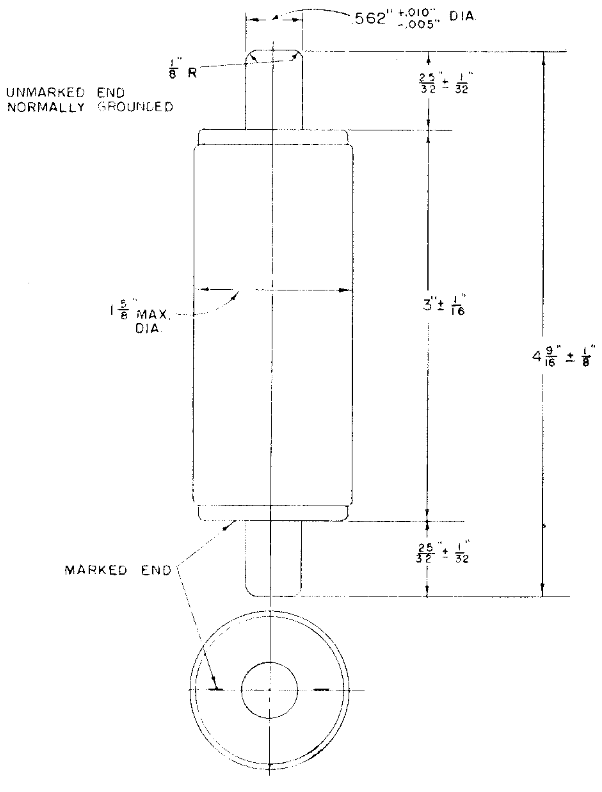
Technical Information

These data are for reference only. For design information see the specifications.

	Capacitance ± 5 Per Cent	Max Peak Voltage	Ambient Temperature Max	Ambient Temperature Min
GL-1L21	12 μμf	7.5 kv	+65 C	-40 C
GL-1L33	100 μμf	7.5 kv	+65 C	-40 C
GL-1L36	25 μμf	7.5 kv	+65 C	-40 C
GL-1L38	50 μμf	7.5 kv	+65 C	-40 C



Outline Vacuum Capacitors
GL-1L21, GL-1L36, and GL-1L38
K-5964469 11-23-43



Outline Vacuum Capacitor
GL-1L33
K-5964459 11-23-43

4-44 (7M)
Filing No. 8850

Supersedes GET-914

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

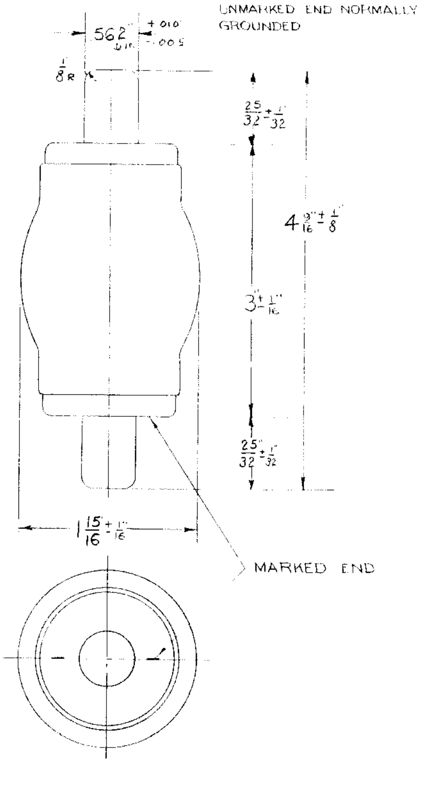
Vacuum Capacitors GL-1L22, GL-1L23 and GL-1L25
Description and Rating

These vacuum capacitors are designed for circuits where the peak voltage is 16,000 volts. Among the advantages of these capacitors is their small size which permits a more compact design than that of air capacitors.

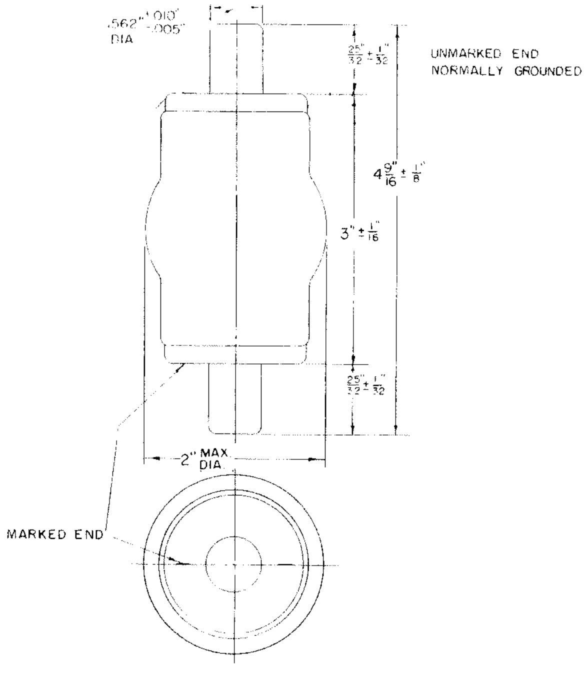
TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

	Capacitance ±5%	Max Peak Voltage	Ambient Temperature Max	Ambient Temperature Min
GL-1L22	25 μμf	16 kv	+65 C	-40 C
GL-1L23	50 μμf	16 kv	+65 C	-40 C
GL-1L25	12 μμf	16 kv	+65 C	-40 C



Outline Vacuum Capacitor
GL-1L22
K-8277098 11-23-43



Outline Vacuum Capacitors
GL-1L23 and GL-1L25
K-8639363 11-23-43

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.
4-44 (7M)
Filing No. 8850

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Thyratron GL-3C23--Description and Rating

The GL-3C23 thyratron is designed for use in regulated-rectifier circuits. The use of a gas mixture of argon and mercury vapor provides constancy of characteristics within wide temperature limits. The construction, however, enables the tube to withstand higher voltages than many gas-filled types.

Technical Information

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Electrical

Number of Electrodes			3
Cathode, Type			Coated-filament
Voltage			2.5 Volts
Current, approx			7.0 Amperes
Heating Time			15 Seconds
Tube Peak Voltage Drop, approx			15 Volts
Approximate Control Characteristics			
Anode Voltage	100	500	25 Volts
Grid Voltage	-2.5	-4.5	0 Volts
Approximate Anode to Grid Capacitance			1.8 uuf
Deionization Time, approx			1000 Microsec
Ionization Time, approx			10 Microsec

Mechanical

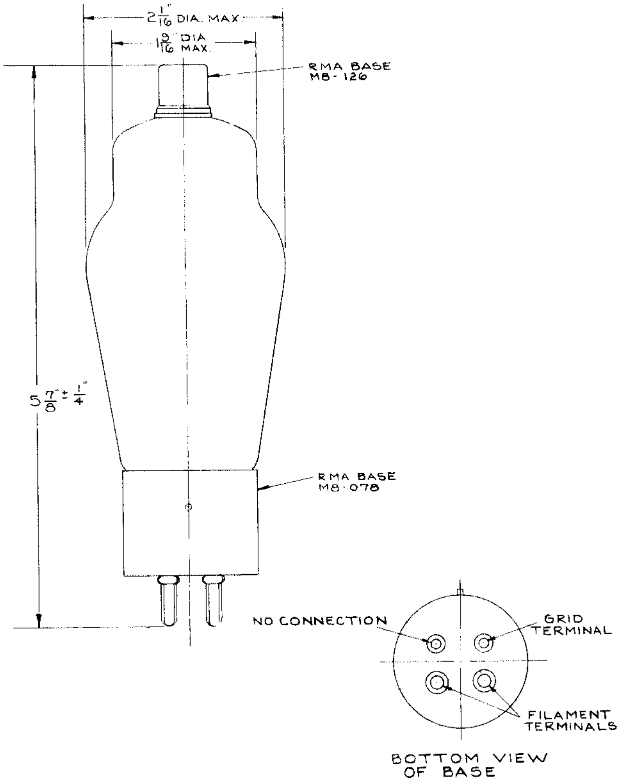
Over-all Dimensions	
Maximum Length	6 1/8 Inches
Maximum Diameter	2 1/16 Inches
Base	Medium 4-Pin Bayonet, M8-078
Cap	M8-128
Net Weight, approx	3 Ounces
Shipping Weight, approx	3 Pounds

MAXIMUM RATINGS

Maximum Peak Anode Voltage	
Inverse	1000 Volts
Forward	1000 Volts
Maximum Negative Grid Voltage	
Before Conduction	500 Volts
During Conduction	10 Volts

MAXIMUM RATINGS (CONT'D)

Maximum Anode Current	
Instantaneous	
25 cycles and above	6.0 Amperes
Below 25 cycles	3.0 Amperes
Average	
210 to 400 cycles	1.0 Ampere
Below 210 cycles	1.5 Ampere
Surge, for design only	55 Amperes
Maximum Grid Current	
Instantaneous	0.050 Ampere
Average	0.010 Ampere
Maximum Time of Averaging Current	5 Sec
Temperature Limits, Condensed mercury	-40 to +80 C



Outline for Thyratron GL-3C23
K-8639392 7-3-43

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-146--Description and Rating

The GL-146 is a three-electrode tube designed for use as a zero-bias Class B amplifier. It may be used also as a Class C amplifier.

TECHNICAL INFORMATION

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	10	Volts
Filament Current	3.25	Amperes
Amplification Factor, I_b = 90 ma	75	
Grid-plate Transconductance	3900	Micromhos
Direct Interelectrode Capacitances:		
Grid-plate	8.4	uuf
Input	7.6	uuf
Output	3.5	uuf

Mechanical

Base	4310	
Net Weight, approximate	14	Ounces
Shipping Weight, approximate	3	Pounds
Installation and operation	GEH-980	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B A-F POWER AMPLIFIER (TWO TUBES)	Typical Operation		Maximum Ratings	
D-c Plate Voltage	1000	1250	1500	Volts
Max Signal Plate Current, per tube	0.160	0.160	0.175	Ampere
D-c Max Signal Plate Input, per tube			250	Watts
Plate Dissipation, per tube			125	Watts
D-c Grid Voltage	0	0		Volts
Zero Signal Plate Current	.02	.034		Ampere
Max Signal Plate Current	0.32	0.32		Ampere
Max Signal Plate Input*	320	400		Watts
Effect Load Resistance, plate-to-plate	7000	8400		Ohms
Max Signal Plate Power Output	200	250		Watts

CLASS B R-F POWER AMPLIFIER
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	1000	1250	1500	Volts
D-c Grid Voltage	0	0	0	Volts
D-c Plate Current	0.15	0.132	0.175	Ampere
Plate Input			200	Watts
Plate Dissipation			125	Watts
Plate Power Output	45	55		Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE-MODULATED
Carrier conditions per tube for use with a max modulation factor of 1.0

	Typical Operation	Maximum Ratings	
D-c Plate Voltage	1000	1250	Volts
D-c Grid Voltage	-200	-400	Volts
D-c Plate Current	0.16	0.175	Ampere
D-c Grid Current, approximate	0.04	0.06	Ampere
Plate Input		220	Watts
Plate Dissipation		80	Watts
Plate Power Output	100		Watts

	Typical Operation	Maximum Ratings	
CLASS C R-F POWER AMPLIFIER AND OSCILLATOR			
Key-down conditions per tube without modulation†			
D-c Plate Voltage	1250	1500	Volts
D-c Grid Voltage	-150	-400	Volts
D-c Plate Current	0.18	0.20	Ampere
D-c Grid Current, approximate	0.03	0.06	Ampere
Plate Input		300	Watts
Plate Dissipation		125	Watts
Plate Power Output	150		Watts

* Averaged over any audio-frequency cycle.

† Modulation, essentially negative, may be used if the positive peak of audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

GL-146 can be operated at maximum ratings in all classes of service at frequencies as high as 15 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under TECHNICAL INFORMATION.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 60 mc for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

FREQUENCY	15	30	60	Mc
MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT:				
Class B telephony	100	85	69	Per cent
Class C (telephony, plate-modulated (telegraphy	100	75	50	Per cent

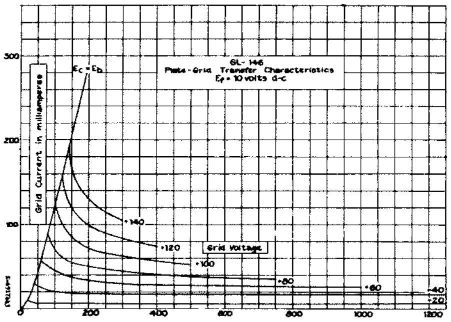
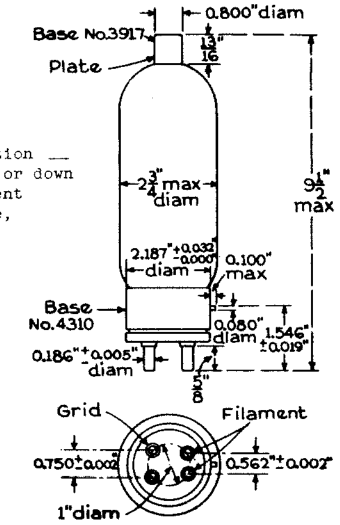
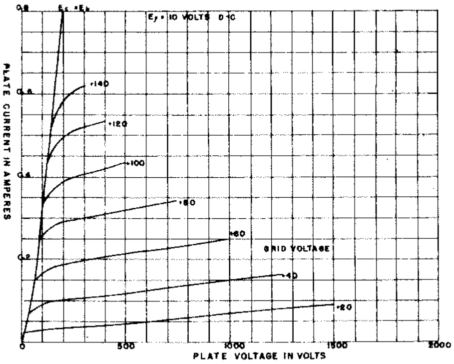


Plate-grid Transfer Characteristics
for Transmitting Tube GL-146
K-6917443 4-10-40



Tube Mounting Position —
Vertical - Base up or down
Horizontal - Filament in vertical plane, on edge

Outline Transmitting Tube GL-146
K-5182000 3-31-42



Average Plate Characteristics
for Transmitting Tube GL-146
K-6917433 6-3-44

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-152--Description and Rating

The GL-152 is a high-vacuum electronic tube for use as a Class B or C amplifier.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Number of Electrodes	3	

Electrical

Cathode - filamentary		
Voltage	10	Volts
Current	3.25	Amperes
Average Characteristics		
Amplification Factor	25	
Grid-plate Transconductance	4000	Micromhos
Direct Interelectrode Capacitances		
Grid-plate	8.4	Micromicrofarads
Grid-filament	7.5	Micromicrofarads
Plate-filament	3.9	Micromicrofarads
Frequency for Maximum Ratings	15	Megacycles

Mechanical

Type of Cooling - Convection		
Maximum Ambient Temperature	60	C
Net Weight, approximate	14	Ounces
Installation and Operation -	GEH-980	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B AUDIO-FREQUENCY POWER AMPLIFIER (Two Tubes)

	Typical Operation	Maximum Ratings	
D-c Plate Voltage	1250	1500	Volts
Maximum Signal D-c Plate Current, per tube†		175	Milliamperes
D-c Max Signal Plate Input, per tube†		250	Watts
Plate Dissipation, per tube†		125	Watts
D-c Grid Voltage	-40		Volts
Zero Signal D-c Plate Current	16		Milliamperes
Maximum Signal D-c Plate Current	320		Milliamperes
Effective Load, plate-to-plate	8400		Ohms
Maximum Signal Plate Power Output, approximate	250		Watts

CLASS B RADIO-FREQUENCY POWER AMPLIFIER
Carrier Conditions per Tube for Use with a Maximum Modulation Factor of 1.0

D-c Plate Voltage	1250	1500	Volts
D-c Grid Voltage	-40		Volts
D-c Plate Current	132	175	Milliamperes

CLASS B RADIO-FREQUENCY POWER AMPLIFIER (CONT'D)
Carrier Conditions per Tube for Use with a Maximum Modulation Factor of 1.0 (Cont'd)

	Typical Operation	Maximum Ratings	
Plate Input		200	Watts
Plate Dissipation		125	Watts
Plate Power Output, approximate	55		Watts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR, PLATE-MODULATED
Carrier Conditions per Tube for Use with a Maximum Modulation Factor of 1.0

	Typical Operation	Maximum Ratings	
D-c Plate Voltage	1000	1250	Volts
D-c Grid Voltage	-200	-400	Volts
D-c Plate Current	160	175	Milliamperes
D-c Grid Current, approximate	30	60	Milliamperes
Plate Input		220	Watts
Plate Dissipation		80	Watts
Plate Power Output	100		Watts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR
Key-down Conditions per Tube without Modulation‡

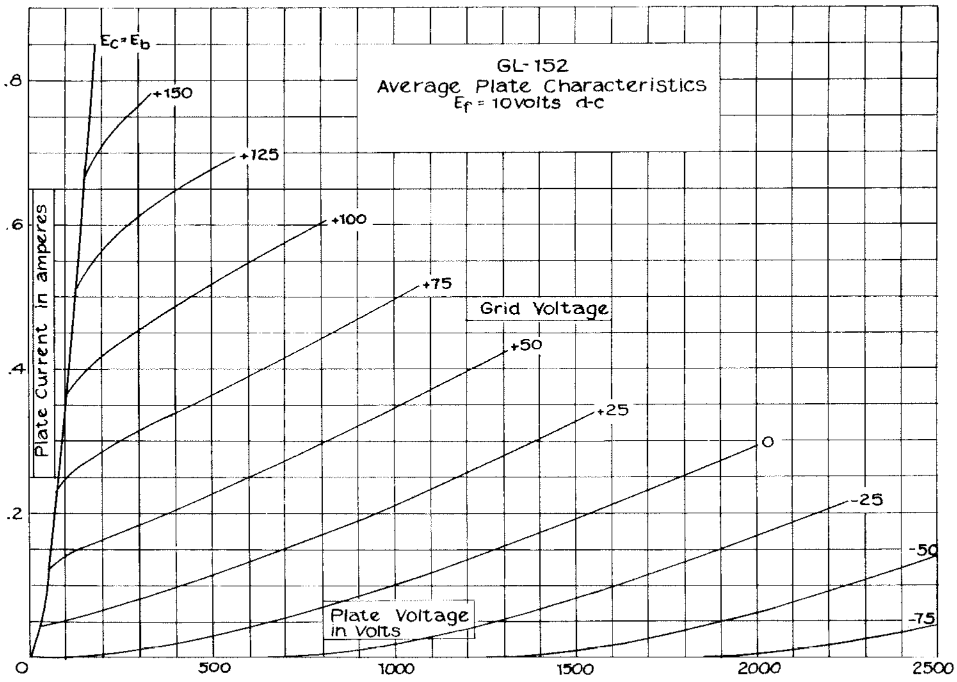
	Typical Operation	Maximum Ratings	
D-c Plate Voltage	1250	1500	Volts
D-c Grid Voltage	-150	-400	Volts
D-c Plate Current	180	200	Milliamperes
D-c Grid Current, approximate	30	60	Milliamperes
Plate Input		300	Watts
Plate Dissipation		125	Watts
Plate Power Output, approximate	150		Watts

The GL-152 can be operated at frequencies as high as 15 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 60 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

FREQUENCY	15	30	60	Megacycles
PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT				
Class B	100	85	69	Per cent
Class C Plate Modulated	100	75	50	Per cent
Class C Unmodulated	100	75	50	Per cent

* Averaged over any audio-frequency cycle

‡ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.



Average Plate Characteristics
for Transmitting Tube GL-152
K-6917441 10-17-39

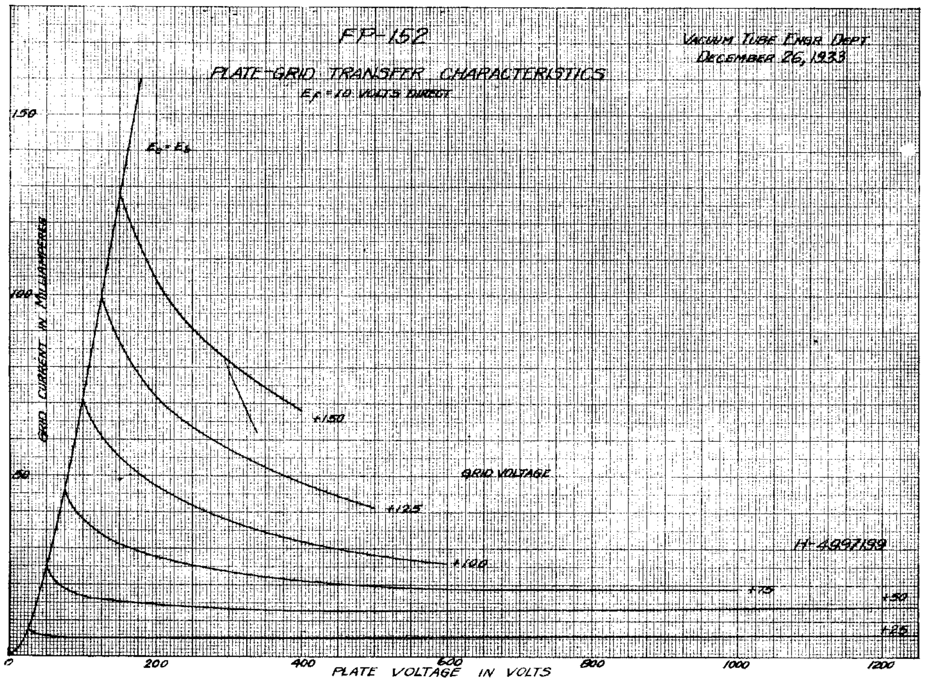
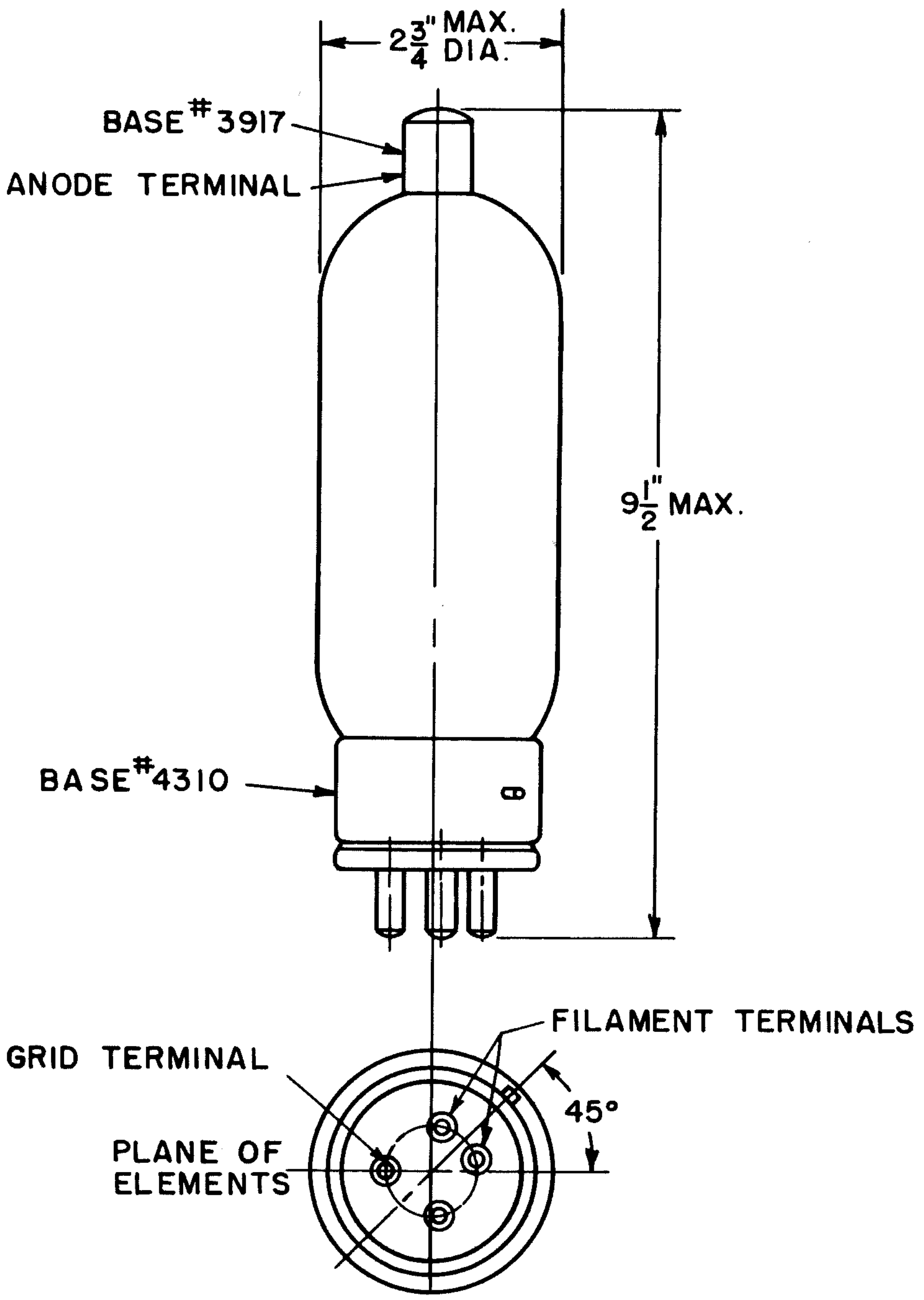


Plate-grid Transfer Characteristics
for Transmitting Tube GL-152
H-4997199 12-26-33



Outline Transmitting Tube GL-152
K-5182000 6-9-44

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-159--Description and Rating

The GL-159 is a high-vacuum transmitting tube designed for use as a Class B and C amplifier.

Technical Information

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Number of Electrodes	3

Electrical

Cathode - Filamentary	
Filament Voltage	10 Volts
Filament Current	9.6 Amperes
Average Characteristics, Eb = 2000, Ib = 100 ma, E_f = 10 v a-c	
Grid Voltage	-80 Volts
Amplification Factor	20
Grid-plate Transconductance	6500 Micromhos
Direct Interelectrode Capacitances	
Grid-plate	17.6 Micromicrofarad
Input	11 Micromicrofarad
Output	5 Micromicrofarad
Frequency for Maximum Ratings	15 Megacycles

Mechanical

Type of Cooling - Convection	
Maximum Ambient Temperature 60 C	
Net Weight, approximate	1 Pound
Shipping Weight, approximate	3 Pounds
Installation and Operation - ET-H15	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B AUDIO-FREQUENCY POWER AMPLIFIER (Two Tubes)

	Typical Operation		Maximum Ratings	
D-c Plate Voltage	1500	2000	2000	Volts
Max Signal D-c Plate Current, per tube †			400	Amperes
D-c Max Signal Plate Input, per tube †			750	Watts
Plate Dissipation, per tube †			250	
D-c Grid Voltage	-73	-100		Volts
Peak A-f Grid Input Voltage	370	400		Volts
Zero Signal Plate Current	0.030	0.030		Amperes
Max Signal Plate Current	0.720	0.660		Amperes
Max Driving Power, approximate	5	4		Watts
Effective Load, plate-to-plate	4400	6880		Ohms
Max Signal Plate Power Output, approximate	720	900		Watts

CLASS B RADIO-FREQUENCY POWER AMPLIFIER
Carrier Conditions Per Tube for Use With a Maximum Modulation Factor of 1.0

	Typical Operation		Maximum Ratings	
D-c Plate Voltage	1500	2000	2000	Volts
D-c Grid Voltage	-65	-90		Volts
D-c Plate Current	0.240	0.190	0.300	Amperes
Plate Input			400	Watts
Plate Dissipation			250	Watts
Peak R-f Grid Input Voltage	200	200		Volts
Driving Power Output, § approximate	3.5	2.5		Watts
Plate Power Output, approximate	120	130		Watts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR- PLATE-MODULATED
Carrier Conditions Per Tube for Use With a Maximum Modulation Factor of 1.0

	Typical Operation			Maximum Ratings	
D-c Plate Voltage	1250	1500	1500	1500	Volts
D-c Grid Voltage	-200	-240	-240	-400	Volts
D-c Plate Current	0.360	0.360	0.400	0.400	Amperes
Plate Input				600	Watts
Plate Dissipation				150	Watts
Peak R-f Grid Input Voltage	350	390	400		Volts
Driving Power	7	7	9		Watts
Plate Power Output	330	400	450		Watts

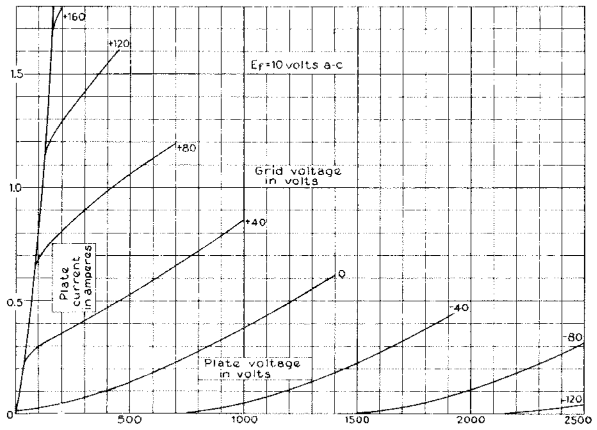
CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR
‡Key Down Conditions Per Tube Without Modulation

	Typical Operation			Maximum Ratings	
D-c Plate Voltage	1500	2000	2000	2000	Volts
D-c Grid Voltage	-150	-200	-200	-400	Volts
D-c Plate Current	0.360	0.360	0.400	0.400	Amperes
D-c Grid Current, approximate	0.014	0.014	0.017	0.100	Amperes
Plate Input				800	Watts
Plate Dissipation				250	Watts
Peak R-f Grid Input Voltage, approximate	295	340	350		Volts
Driving Power, approximate	4	5	6		Watts
Plate Power Output, approximate	400	560	620		Watts

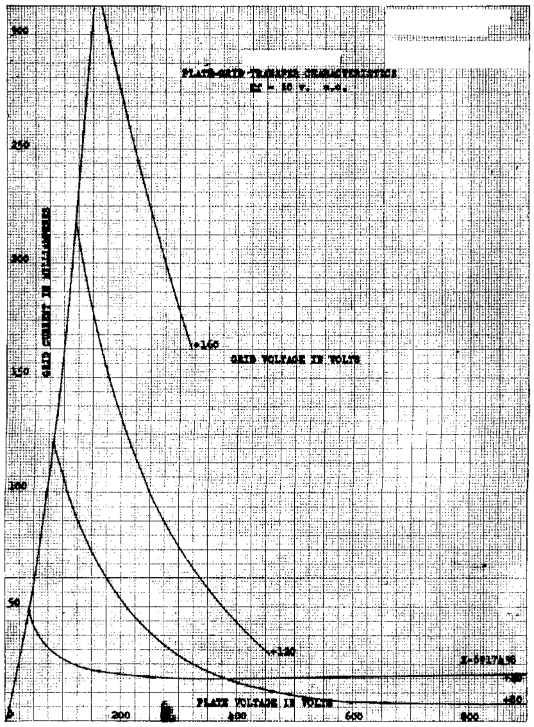
‡ Modulation, essentially negative, may be used if the positive peak of the Audio-frequency envelope does not exceed 115 per cent of the carrier conditions.
§ At crest of audio-frequency cycle.
† Averaged over any audio-frequency cycle.

The GL-159 can be operated at frequencies as high as 15 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 35 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

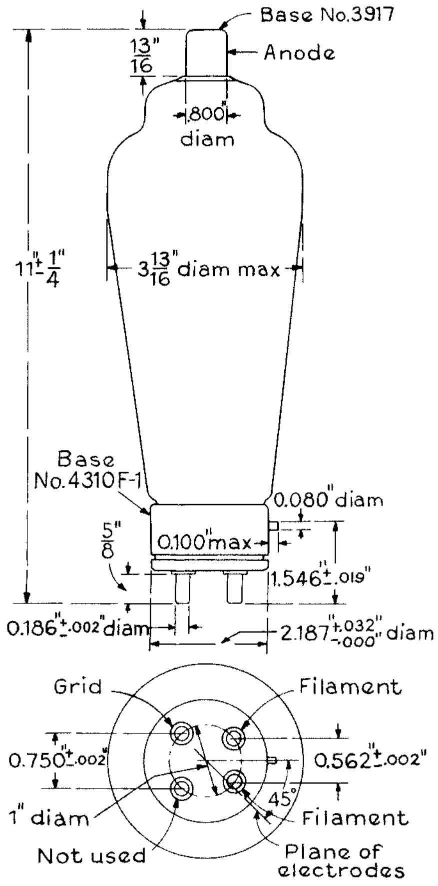
FREQUENCY	15	25	35	Megacycles
PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT				
Class B	100	85	74	Per cent
Class C Plate Modulated	100	75	50	Per cent
Class C Unmodulated	100	75	50	Per cent



Average Plate Characteristics for GL-159
H-5178580 1-31-36



K-6917438 11-3-39



Outline GL-159
K-5302943 7-23-35

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-169--Description and Rating

The GL-169 is designed for use as a Class B or C amplifier.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Number of Electrodes	3
Electrical	
Cathode - Filamentary	
Voltage	10 Volts
Current	9.6 Amperes
Average Characteristics, Eb = 2000, Ib = 100 ma, E_f = 10 a-c	
Grid Voltage	-4 Volts
Amplification Factor	85
Grid-plate Transconductance, I_b = 100 ma	7500 Micromhos
Direct Interelectrode Capacitances	
Grid-plate	19 μμf
Grid-filament	11.5 μμf
Plate-filament	4.7 μμf
Frequency for Maximum Ratings	15 Megacycles
Mechanical	
Type of Cooling - Convection	
Maximum Ambient Temperature 60 C	
Net Weight, approximate	1 Pound
Shipping Weight, approximate	3 Pounds
Installation and Operation - ET-H15	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B AUDIO-FREQUENCY POWER AMPLIFIER (TWO TUBES)

	Typical Operation		Maximum Ratings	
D-c Plate Voltage	1500	2000	2000	Volts
Max Signal Plate Current, per tube†			0.400	Amperes
D-c Max Signal Plate Input, per tube†			750	Watts
Plate Dissipation, per tube†			250	Watts
A-c Grid Voltage	-12	-18		Volts
Peak A-f Grid Input Voltage	220	220		Volts
Zero Signal Plate Current	0.030	0.030		Amperes
Max Signal Plate Current	0.720	0.660		Amperes
Max Signal Driving Power, approximate	8	6		Watts
Effective Load, plate-to-plate	4600	7000		Ohms
Max Signal Plate Power Output, approximate	720	900		Watts

CLASS B RADIO-FREQUENCY POWER AMPLIFIER
Carrier conditions per tube for use with a maximum modulation factor of 1.0

	Typical Operation		Maximum Ratings	
D-c Plate Voltage	1500	2000	2000	Volts
A-c Grid Voltage	-5	-10		Volts
D-c Plate Current	0.240	0.190	0.300	Amperes
Plate Input			400	Watts
Plate Dissipation			250	Watts
Peak R-f Grid Input Voltage	110	110		Volts
Driving Power§, approximate	5	3.5		Watts
Plate Power Output, approximate	120	130		Watts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR, PLATE-MODULATED
Carrier conditions per tube for use with a maximum modulation factor of 1.0

	Typical Operation			Maximum Ratings	
D-c Plate Voltage	1250	1500	1500	1500	Volts
D-c Grid Voltage	-80	-100	-100	-400	Volts
D-c Plate Current	0.360	0.360	0.400	0.400	Amperes
D-c Grid Current, approximate	0.045	0.040	0.045	0.100	Amperes
Plate Input				600	Watts
Plate Dissipation				150	Watts
Peak R-f Grid Input Voltage	210	230	240		Volts
Driving Power	9	8.5	10		Watts
Plate Power Output	330	400	450		Watts

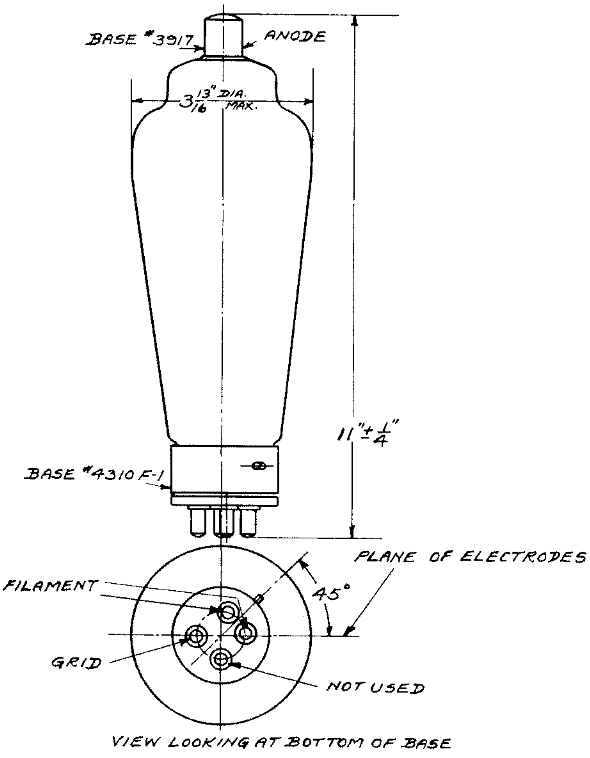
CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR
Key-down conditions per tube without modulation‡

	Typical Operation			Maximum Ratings	
D-c Plate Voltage	1500	2000	2000	2000	Volts
D-c Grid Voltage	-50	-100	-100	-400	Volts
D-c Plate Current	0.360	0.360	0.400	0.400	Amperes
D-c Grid Current, approximate	0.038	0.037	0.042	0.100	Amperes
Plate Input				800	Watts
Plate Dissipation				250	Watts
Peak R-f Grid Input Voltage, approximate	170	230	240		Volts
Driving Power, approximate	6	8	10		Watts
Plate Power Output, approximate	400	560	620		Watts

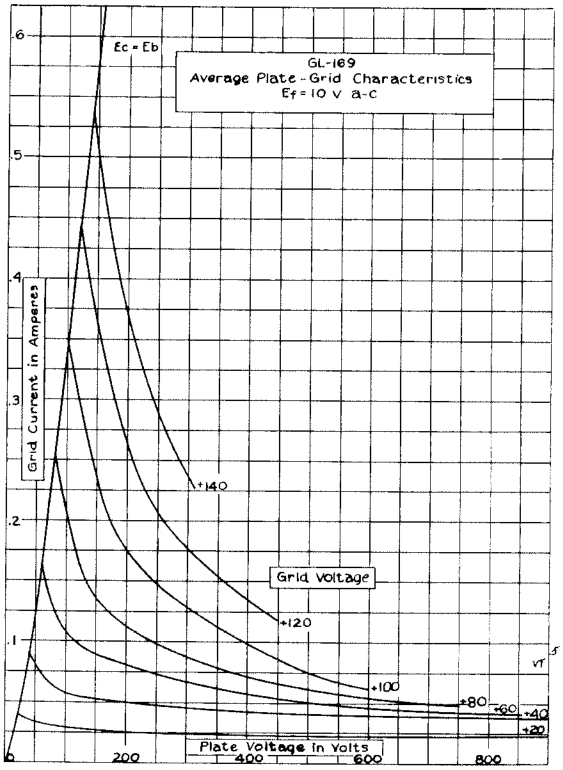
† Averaged over any audio-frequency cycle
§ At crest of audio-frequency cycle
‡ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

The GL-169 can be operated at frequencies as high as 15 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 35 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

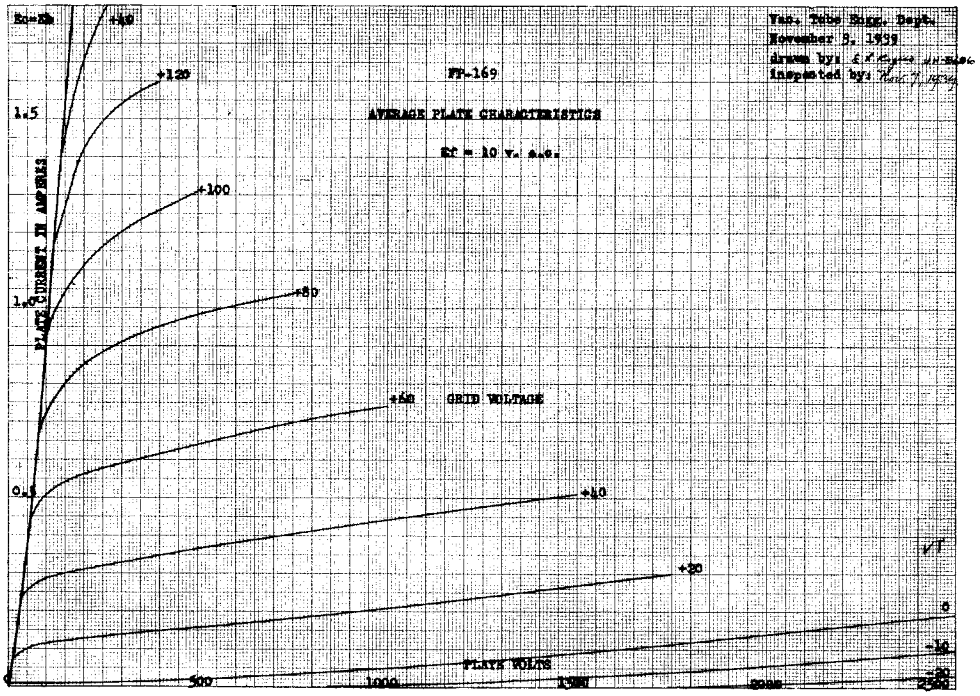
FREQUENCY	15	25	35	Megacycles
PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT				
Class B	100	85	74	Per cent
Class C Plate Modulated	100	75	50	Per cent
Class C Unmodulated	100	75	50	Per cent



Outline Transmitting
Tube GL-169
K-5302943 7-23-35



Average Plate-grid Characteristics
for Transmitting Tube GL-169
K-6917442 4-16-40



Average Plate Characteristics of
Transmitting Tube GL-169
K-6917439 11-3-39

GENERAL ELECTRIC

Transmitting Tube GL-203-A - - Description and Rating

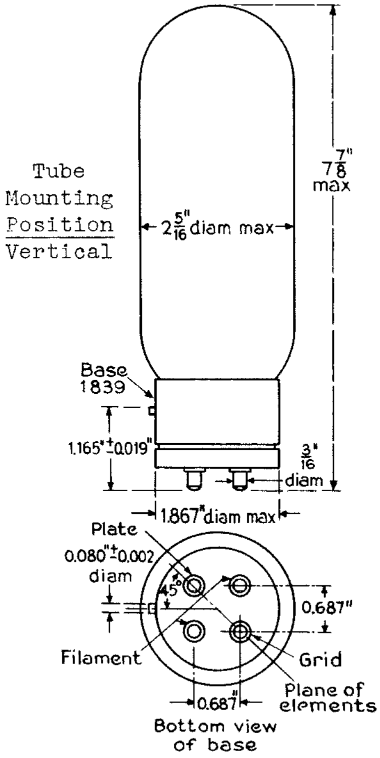
The transmitting tube GL-203A is a three-electrode tube designed for use as a Class B and C power amplifier.

Technical Information

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS:

Filament Voltage, volts	10
Filament Current, amperes	3.25
Amplification Factor Ib = 72 ma	25
Grid-Plate Transconductance, mmhos	4200
Direct Interelectrode Capacitances, uuf	
Grid-plate	14.5
Input	6.5
Output	5.5
Base or Terminal Description	Jumbo, 4-Large Pin
Net Weight, oz approx	7.5
Shipping Weight, lb approx	7
Installation and Operation Instructions	GEH-980

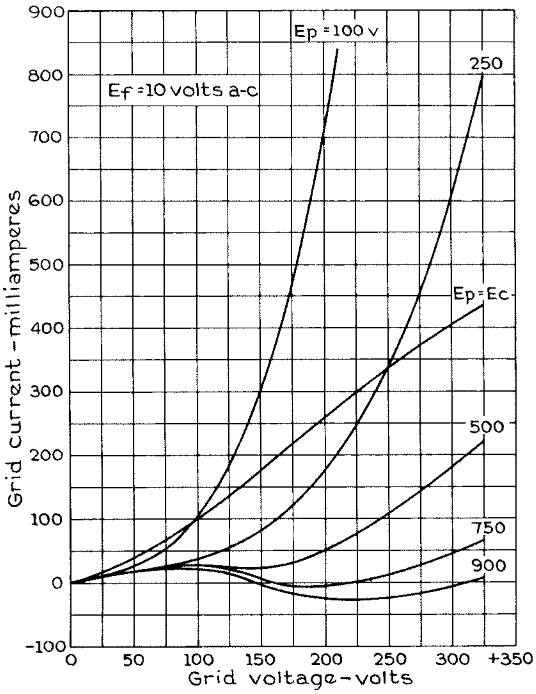


Outline Transmitting Tube GL-203-A
K-4909036 9-20-39

* Averaged over an audio-frequency cycle

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

	Typical Operation		Max Ratings
CLASS B A-F POWER AMPLIFIER (TWO TUBES):			
D-c Plate Voltage, v	1000	1250	1250
Maximum Signal Plate Current (per tube)*, amp	--	--	.175
D-c Maximum Signal Plate Input (per tube)*, w	--	--	220
Plate Dissipation* (per tube), w	--	--	100
D-c Grid Voltage, v	-30	-40	--
Zero Signal Plate Current, ma	26	26	--
Maximum Signal Plate Current, ma	320	320	--



Average Grid Characteristics of Transmitting Tube GL-203-A
K-6917428 10-3-39

	Typical Operation		Max Ratings
Maximum Signal Driving Power, approx w	10	11	--
Effective Load (plate to plate), ohms	6900	9000	--
Maximum Signal Plate Power Output, w	200	260	--

CLASS B R-F POWER AMPLIFIER:
(Carrier conditions per tube for use with a maximum modulation factor of 1.0)

	Typical Operation		Max Ratings
D-c Plate Voltage, v	1000	1250	1250
D-c Grid Voltage, v	-30	-40	--
D-c Plate Current, amp	.130	.106	.150
Plate Input, w	--	--	150
Plate Dissipation, w	--	--	100
Peak R-f Grid Input Voltages, v	95	90	--
D-c Grid Current, approx ma	5	3	--
Driving Power †, approx w	5	3	--
Plate Power Output, w	40	42.5	--

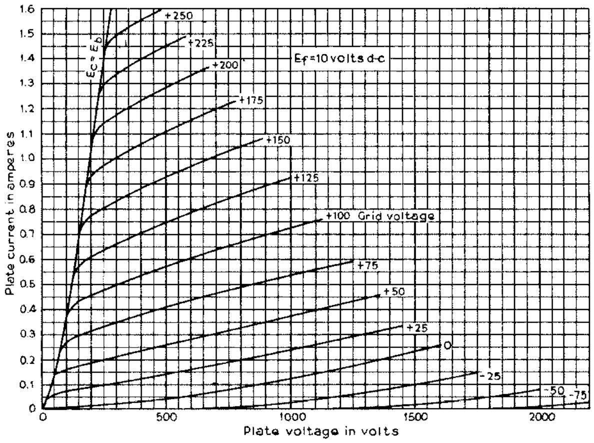
CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED:
(Carrier conditions per tube for use with a maximum modulation factor of 1.0)

	Typical Operation		Max Ratings
D-c Plate Voltage, v	750	1000	1000
D-c Grid Voltage, v	-100	-135	-400
D-c Plate Current, amp	.150	.150	.175
D-c Grid Current, approx amp	.050	.050	.060
Plate Input, w	--	--	175
Plate Dissipation, w	--	--	67
Peak R-f Grid Input Voltage, approx w	235	275	--
Driving Power, approx w	12	14	--
Plate Power Output	65	100	--

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR:
(Key down conditions per tube without modulation)‡

	Typical Operation			Max Ratings
D-c Plate Voltage, v	750	1000	1250	1250
D-c Grid Voltage, v	-75	-100	-125	-400
D-c Plate Current, amp	.150	.150	.150	.175
D-c Grid Current, approx amp	.025	.025	.025	.060
Plate Input, w	--	--	--	220
Plate Dissipation, w	--	--	--	100

	Typical Operation			Max Ratings
Peak R-f Grid Input Voltage, approx v	195	225	255	--
Driving Power, approx w	5	6	7	--
Plate Power Output, w	65	100	130	--



Average Plate Characteristics of Transmitting Tube GL-203-A
K-5917424. 10-3-39

The normal value of grid leak, when the tube is used as an oscillator or r-f power amplifier (Class C), is in the neighborhood of 5000 ohms, although this may be replaced by a suitable fixed bias. If self-bias is used the cathode resistor should be approximately 600 ohms.

The maximum ratings apply only at frequencies below 15 megacycles. For operation at higher frequencies adequate ventilation and normal ambient temperatures must be maintained, and the plate voltage must be reduced as indicated.

Frequency, Megacycles	15	30	80
Percentage of Maximum Rated Plate Voltage and Plate Input	100	75	50

The resonant frequency of the grid-plate circuit is approximately 100 megacycles.

† At crest of audio-frequency cycle.
‡ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.
10-41 (3M)
Filing No. 8850
Supersedes GET-501C

GENERAL ELECTRIC

Transmitting Tube GL-204-A—Description and Rating

TECHNICAL INFORMATION

The GL-204-A is a three-electrode vacuum tube designed for use as a Class B and C amplifier.

These data are for reference only. For design information, see the specifications.

CHARACTERISTICS AND RATINGS

Filament Voltage	11	Volts
Filament Current	3.85	Amperes
Amplification Factor (I_b = 125 ma)	23	
Grid-plate Transconductance	4000	Micromhos
Direct Interelectrode Capacitances:		
Grid-plate	15	μμf
Input	12.5	μμf
Output	2.3	μμf
Base	3502	
Frequency for Maximum Ratings	3	Megacycles
Net Weight (approx)	3	Pounds

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B A-F POWER AMPLIFIER (TWO TUBES)

D-c Plate Voltage	2000	2500	3000	3000 max	Volts
Maximum Signal Plate Current (per tube)*				0.275 max	Ampere
D-c Maximum Signal Plate Input (per tube)*				650 max	Watts
Plate Dissipation (per tube)*				250 max	Watts
D-c Grid Voltage	-60	-80	-100		Volts
Peak A-f Grid Input Voltage	500	500	500		Volts
Zero Signal Plate Current	0.080	0.080	0.080		Ampere
Maximum Signal Plate Current	0.5	0.42	0.37		Ampere
Maximum Signal Plate Input*	1000	1050	1100		Watts
Maximum Signal Driving Power (approx)	20	18	18		Watts
Effective Load (plate-to-plate)	8800	13600	20000		Ohms
Maximum Signal Plate Power Output	600	650	700		Watts

CLASS B R-F POWER AMPLIFIER
Carrier conditions per tube for use with a maximum modulation factor of 1.0

D-c Plate Voltage	1500	2000	2500 max	Volts
D-c Grid Voltage	-50	-70		Volts
D-c Plate Current	0.2	0.16	0.225 max	Ampere
Plate Input			400 max	Watts
Plate Dissipation			250 max	Watts
Peak R-f Grid Input Voltage	170	165		Volts
Driving Power (approx)**	18	15		Watts
Plate Power Output	80	100		Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED
Carrier conditions per tube for use with a maximum modulation factor of 1.0

D-c Plate Voltage	1500	2000	2000 max	Volts
D-c Grid Voltage	-200	-250	-500 max	Volts
D-c Plate Current	0.25	0.25	0.275 max	Ampere
D-c Grid Current (approx)	0.035	0.035	0.08 max	Ampere
Plate Input			550 max	Watts
Plate Dissipation			167 max	Watts

Peak R-f Grid Input Voltage (approx)		450	500		Volts
Driving Power (approx)		20	20		Watts
Plate Power Output		225	350		Watts

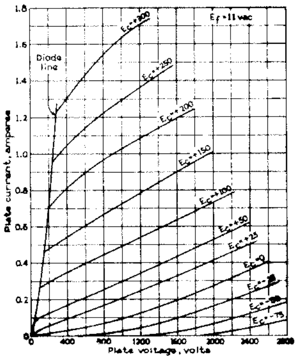
CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
Key-down conditions per tube without modulation†

D-c Plate Voltage	1500	2000	2500	2500 max	Volts
D-c Grid Voltage	-150	-175	-200	-500 max	Volts
D-c Plate Current	0.25	0.25	0.25	0.275 max	Ampere
D-c Grid Current (approx)	0.03	0.03	0.03	0.08 max	Ampere
Plate Input				690 max	Watts
Plate Dissipation				250 max	Watts
Peak R-f Grid Input Voltage(approx)	400	425	440		Volts
Driving Power (approx)	15	15	15		Watts
Plate Power Output	240	350	450		Watts

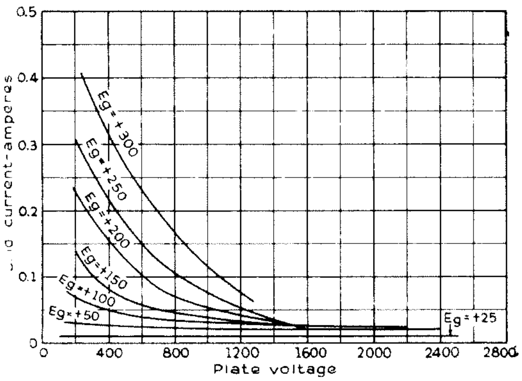
* Averaged over any audio-frequency cycle.
** At crest of audio-frequency cycle.
† Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

GL-204-A can be operated at maximum ratings in all classes of service at frequencies as high as 3 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under TECHNICAL INFORMATION.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 30 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

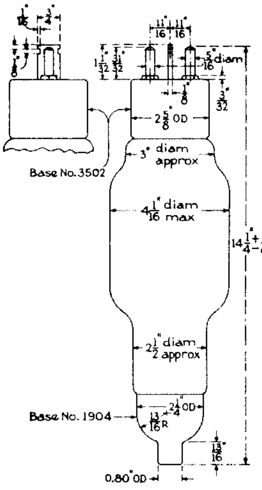
FREQUENCY	3	10	30	Mc
MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT:				
Class B Telephony	100	84	69	Per Cent
Class C (Telephony, plate-modulated (Telegraphy	100	75	50	Per Cent



Average Plate Characteristics for Transmitting Tube GL-204-A



Average Grid-plate Characteristics for Transmitting Tube GL-204-A
K-7000101 6-3-35



Outline Transmitting Tube GL-204-A
K-2109055 12-13-39

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-207--Description and Rating

Technical Information

The GL-207 is a three-electrode, water-cooled vacuum tube designed for use as a radio-frequency power amplifier, oscillator, or Class B modulator.

These data for reference only. For equipment design see specifications.

GENERAL CHARACTERISTICS

Electrical

Filament - Tungsten	
Voltage	22 Volts
Current	51 Amperes
Average Characteristics, E_b = 10,000, I_b = 750 ma, E_f = 22	
Grid Voltage	-310 Volts
Amplification Factor	20
Grid-plate Transconductance, I_b = 750 ma	5700 Micromhos
Direct Interelectrode Capacitances	
Grid-plate	27 uuf
Input	18 uuf
Output	2.5 uuf
Frequency for Maximum Ratings	1.6 Megacycles

Mechanical

Type of Cooling - Water	
Water flow	3 - 8 Gpm
Maximum outlet Temperature	70 C
Base Description	3906
Gasket	Cat. No. 5182028P3
Maximum Over-all Dimensions	
Length	20 1/4 Inches
Radius	6 1/2 Inches
Net Weight, approximate	3 Pounds
Shipping Weight, approximate	10 Pounds
Installation and Operation	GEH-1152

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B AUDIO-FREQUENCY POWER AMPLIFIER, TWO TUBES

	Typical Operation			Maximum Ratings	
D-c Plate Voltage	6000	10000	12500	15000	Volts
Maximum Signal Plate Current, per tube†				2.0	Amperes
D-c Maximum Signal Plate Input, per tube†				20	Kilowatts
Plate Dissipation, per tube†				7.5	Kilowatts
D-c Grid Voltage	-210	-410	-575		Volts
Peak A-F Grid Input Voltage	1520	2140	2300		Volts
Zero Signal Plate Current	0.5	0.5	0.4		Ampere
Maximum Signal Plate Current	2.5	3.2	2.8		Amperes
Maximum Signal Driving Power, approx	190	380	400		Watts
Effective Load, Plate-to-plate	4200	6400	10000		Ohms
Maximum Signal Plate Power Output	8	20	22.5		Kilowatts

†Averaged over any audio-frequency cycle

CLASS B RADIO-FREQUENCY POWER AMPLIFIER
Carrier conditions per tube for use with a maximum modulation factor of 1.0

D-c Plate Voltage	6000	10000	14000	15000	Volts
D-c Grid Voltage	-225	-440	-650		Volts
D-c Plate Current	0.62	0.93	1.0	1.0	Ampere

	Typical Operation			Maximum Ratings
Plate Input				15 Kilowatts
Plate Dissipation				10 Kilowatts
Peak R-f Grid Input Voltage	800	1200	1460	Volts
Driving Power‡, approx	72	16	0	Watts
Plate Power Output	1	2.5	4	Kilowatts

‡At crest of audio-frequency cycle.

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR, PLATE MODULATED
Carrier conditions per tube for use with a maximum modulation factor of 1.0

D-c Plate Voltage	6000	8000	10000	10000 Volts
D-c Grid Voltage	-1200	-1600	-2000	-3000 Volts
D-c Plate Current	0.76	0.78	0.75	1.0 Ampere
D-c Grid Current, approx	0.15	0.14	0.07	0.20 Ampere
Plate Input				10 Kilowatts
Plate Dissipation				6.6 Kilowatts
Peak R-f Grid Input Voltage, approx	1860	2300	2660	Volts
Driving Power, approx	280	325	185	Watts
Plate Power Output	3.5	5	6	Kilowatts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR
Key-down conditions per tube without modulation*

D-c Plate Voltage	8000	10000	12000	15000 Volts
D-c Grid Voltage	-1000	-1200	-1600	-3000 Volts
D-c Plate Current	1.1	1.33	1.67	2.0 Amperes
D-c Grid Current, approx	0.17	0.12	0.09	0.2 Ampere
Plate Input				30 Kilowatts
Plate Dissipation				10 Kilowatts
Peak R-f Grid Input Voltage	1730	2050	2650	Volts
Driving Power, approx	295	245	235	Watts
Plate Power Output	6.5	10	15	Kilowatts

*Modulation, essentially negative, may be used if the positive peak of the Audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

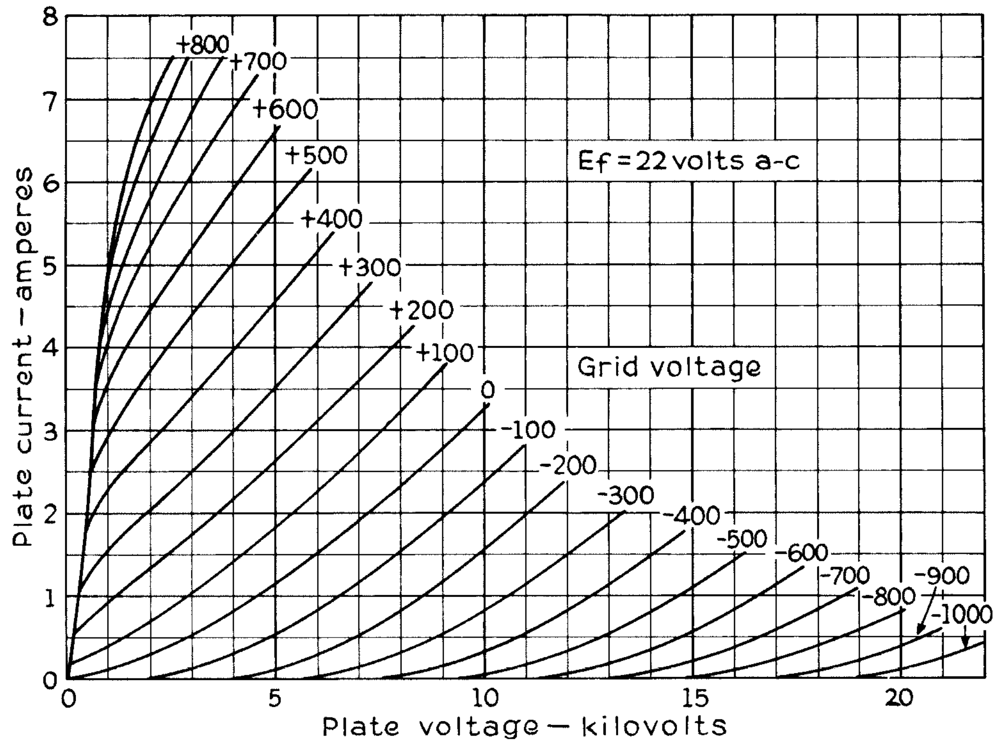
The GL-207 can be operated at frequencies as high as 1.5 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 20 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

FREQUENCY	1.5	7.5	20	Megacycles
PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT				
Class B	100	85	76	Per Cent
Class C Plate Modulated	100	75	50	Per Cent
Class C Unmodulated	100	75	50	Per Cent

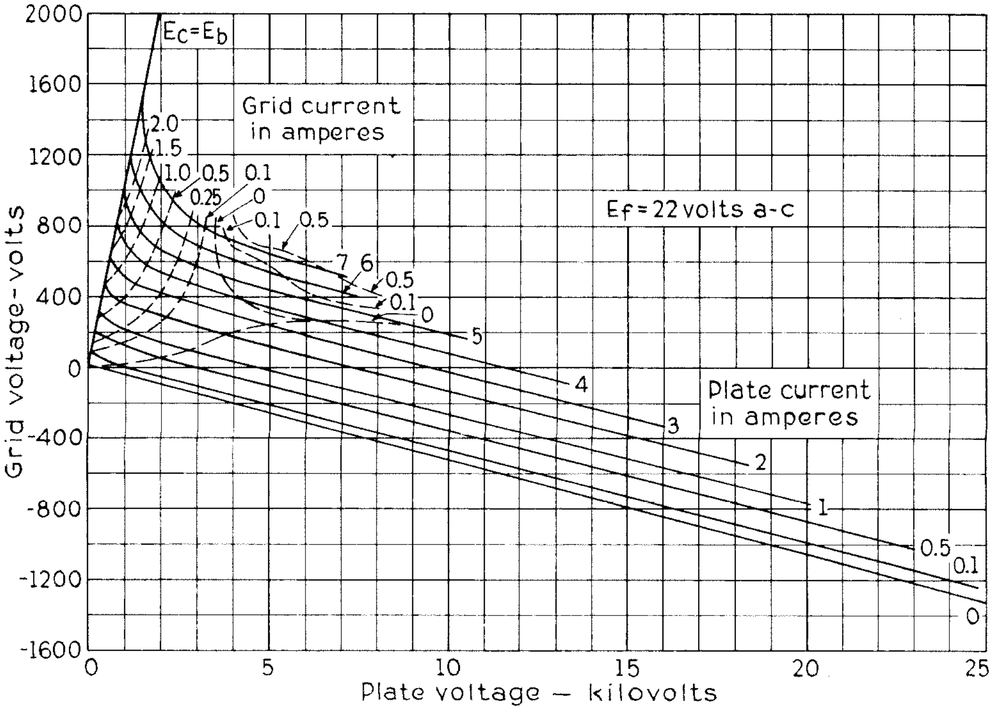
APPLICATION NOTES

Plate Series Protective Resistors (see paragraph describing plate circuit under Installation in the Instructions).

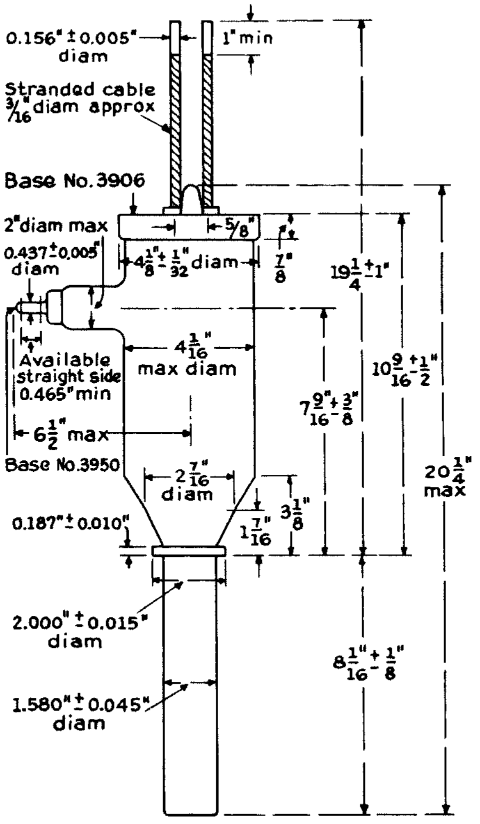
Series Resistor, ohms	25	50	200	250	275	300
Maximum Power Output of Rectifier, kilowatts	16	40	100	250	640	1600



Average Plate Characteristic for Transmitting Tube GL-207
K-6966463 6-12-42



Characteristics for Transmitting Tube GL-207
K-6966464 6-12-42



Outline Transmitting Tube GL-207
K-5182095 5-12-39

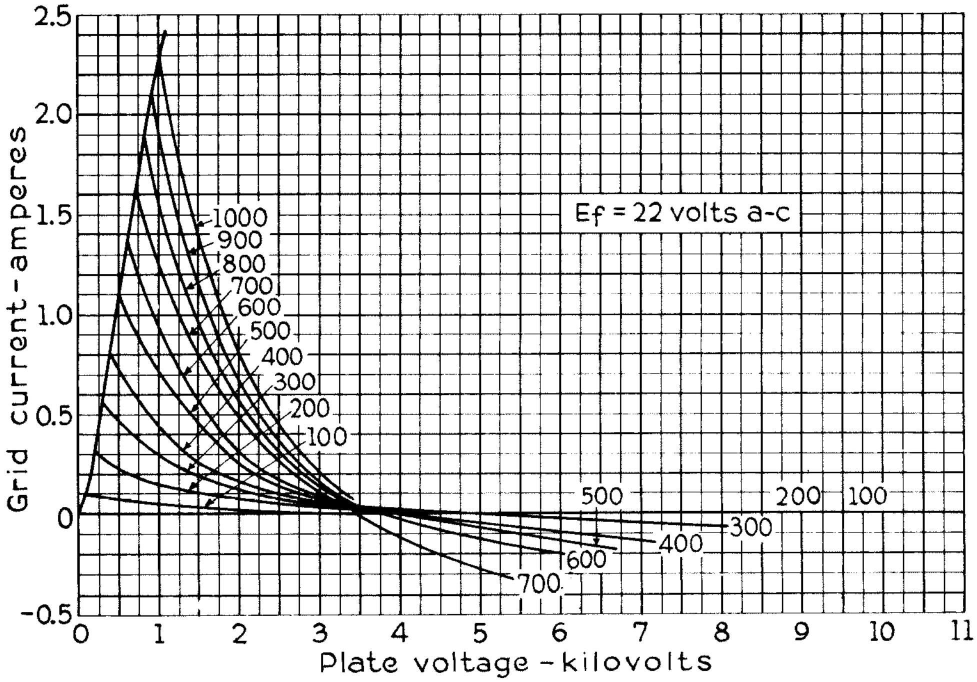


Plate-grid Transfer Characteristic Typical Data
for Transmitting Tube GL-207
K-6966465 6-26-42

4-44 (8M)
Filing No. 8850

Supersedes GET-763A
PRINTED IN U.S.A.

GENERAL ELECTRIC

Transmitting Tube GL-211 -- Description and Rating

The GL-211 is a general-purpose three-electrode transmitting tube which may be used as a Class A, B, or C amplifier. This tube can be operated at maximum ratings at frequencies as high as 15 megacycles.

TECHNICAL INFORMATION

ELECTRICAL		
Filament Voltage	10	volts
Filament Current	3.25	amperes
Amplification Factor	12	
Grid-plate Transconductance, I_b = 60 ma	3600	micromhos
Direct Interelectrode Capacitances		
Grid-plate	14.5	μμf
Input	6	μμf
Output	5.5	μμf
MECHANICAL		
Base Description	Jumbo 4 - Large Pin	
Net Weight, approx	8	ounces
Shipping Weight, approx	4	pounds
Installation and Operation	GEH-980	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS A A-F AMPLIFIER AND MODULATOR

Filament Voltage		10			volts
D-c Plate Voltage	750	1000	1250	1250 max	volts
Plate Dissipation				75 max	watts
D-c Grid Voltage	-46	-61	-75		volts
Peak Grid Swing, approx	41	56	75		volts
D-c Plate Current	34	53	60		milliamperes
Plate Resistance	4400	3800	3600		ohms
Load Resistance	8800	7600	9200		ohms
Plate Power Output, 5% second harmonic	5.6	12	19.7		watts

CLASS B A-F POWER AMPLIFIER (TWO TUBES)

Filament Voltage	10			volts
D-c Plate Voltage	1000	1250	1250 max	volts
Max Signal Plate Current, per tube§			0.175 max	amperes
D-c Max Signal Plate Input, per tube§			220 max	watts
Plate Dissipation, per tube§			100 max	watts
D-c Grid Voltage	-72	-95		volts
Peak A-f Grid Input Voltage	380	410		volts
Zero Signal Plate Current	20	20		milliamperes
Max Signal Plate Current	320	320		milliamperes
Max Signal Driving Power, approx	7.5	8		watts
Effective Load, plate-to-plate	6900	9000		ohms
Max Signal Plate Power Output	200	260		watts

CLASS B R-F POWER AMPLIFIER
Carrier conditions per tube for use with a maximum modulation factor of 1.0

Filament Voltage	10			volts
D-c Plate Voltage	1000	1250	1250 max	volts
D-c Grid Voltage	-72	-95		volts
D-c Plate Current	0.130	0.106	0.150 max	amperes
Plate Input			150 max	watts

Plate Dissipation			100 max	watts
Peak R-f Grid Input Voltage	125	125		volts
D-c Grid Current, approx	5	1		milliamperes
Driving Power†, approx	10	7.5		watts
Plate Power Output	40	42.5		watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR, PLATE MODULATED
Carrier conditions per tube for use with a maximum modulation factor of 1.0

Filament Voltage	10			volts
D-c Plate Voltage	750	1000	1000 max	volts
D-c Grid Voltage	-200	-260	-400 max	volts
D-c Plate Current	0.150	0.150	0.175 max	ampere
D-c Grid Current, approx	0.035	0.035	0.050 max	ampere
Plate Input			175 max	watts
Plate Dissipation			67 max	watts
Peak R-f Grid Input Voltage, approx	350	410		volts
Driving Power, approx	12	14		watts
Plate Power Output	65	100		watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
Key down conditions per tube without modulation‡

Filament Voltage	10				volts
D-c Plate Voltage	750	1000	1250	1250 max	volts
D-c Grid Voltage	-135	-175	-225	-400 max	volts
D-c Plate Current	0.150	0.150	0.150	0.175 max	ampere
D-c Grid Current, approx	0.018	0.018	0.018	0.050 max	ampere
Plate Input				220 max	watts
Plate Dissipation				100 max	watts
Peak R-f Grid Input Voltage, approx	275	315	375		volts
Driving Power, approx	5	6	7		watts
Plate Power Output	65	100	130		watts

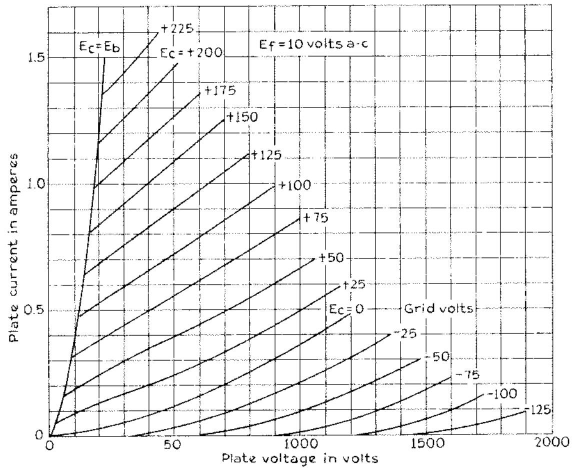
§ Averaged over any audio-frequency cycle.
† At crest of audio-frequency cycle.
‡ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

The normal value of grid leak, when the tube is used as an oscillator or r-f power amplifier (Class C), is in the neighborhood of 5000 ohms, although this may be replaced by a suitable fixed bias. If self-bias is used the cathode resistor should be approximately 1000 ohms.

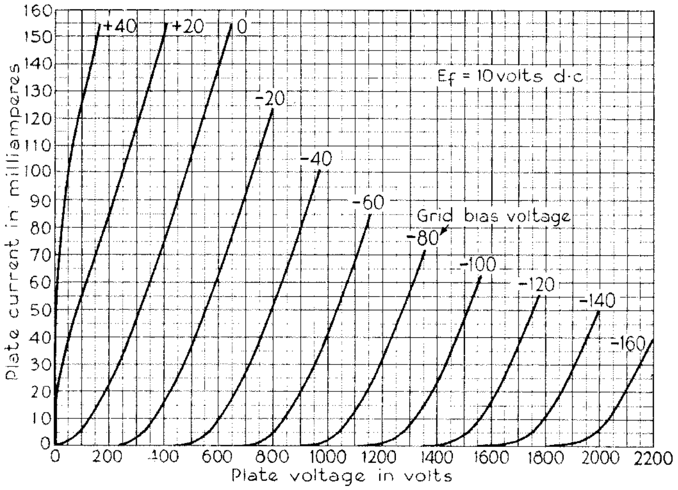
The 211 can be operated at frequencies as high as 15 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 80 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

FREQUENCY	15	30	80	megacycles
PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT				
Class B	100	88	70	per cent
Class C	100	80	50	per cent

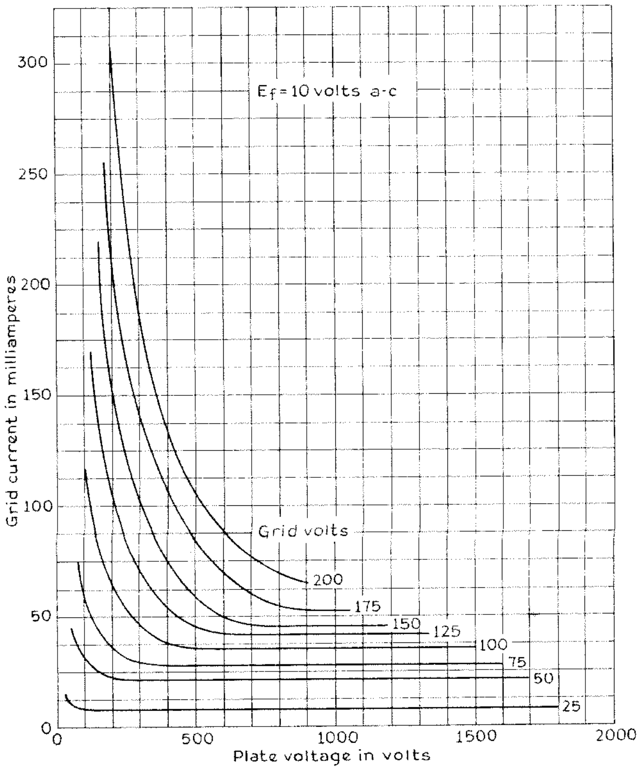
The resonant frequency of the grid-plate circuit is approximately 100 megacycles.



Average Plate Characteristic
K-6917437 11-6-39

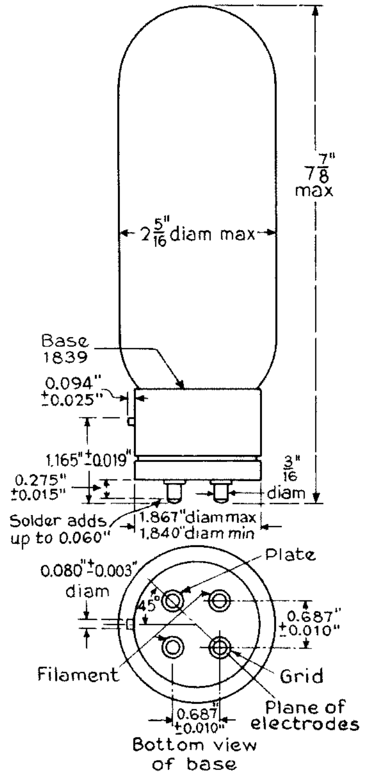


Average Plate Characteristic
K-6917423 10-3-39



Average Characteristic
K-6917435 11-6-39

Tube Mounting Position
Vertical: Base down



Outline Transmitting
Tube GL-211
K-4909036 9-20-39

GENERAL ELECTRIC

SCHENECTADY, N.Y.

6-42 (4M)
Filing No. 8850

Supersedes GET-503B

PRINTED IN U.S.A.

GENERAL ELECTRIC

Transmitting Tube GL-217-C -- Description and Rating

Technical Information

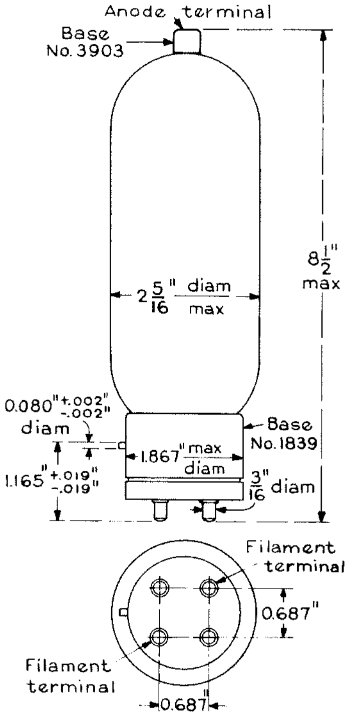
The 217-C is a high-vacuum, half-wave rectifier for use in high-voltage d-c power supply devices operating from the alternating-current supply line.

CHARACTERISTICS AND RATINGS

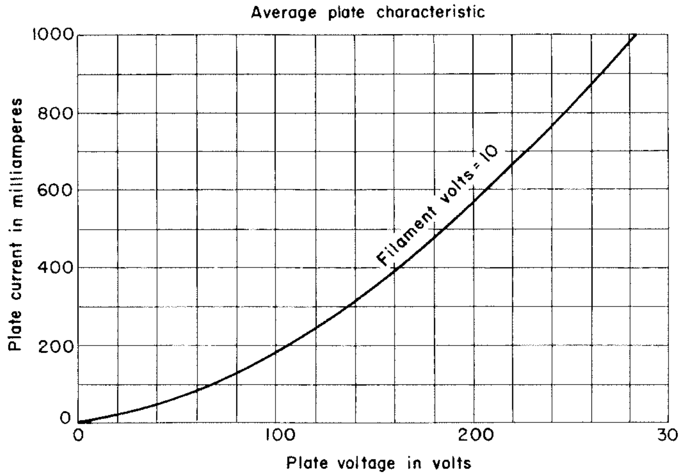
Filament Voltage	10	Volts
Filament Current	3.25	Amperes
Base Description	Jumbo 4-large Pin	
Type of Cooling	Air	
Net Weight, approx	7	Ounces
Shipping Weight, approx	3	Pounds
Installation and Operation	GEH-1066	

MAXIMUM RATINGS

Maximum Peak Inverse Voltage	7500	Volts
Maximum Peak Plate Current	600	Milliamperes
Tube Voltage Drop, I_b = 600	210	Volts



Outline Transmitting Tube GL-217-C
K-5182050 6-26-40



Tube Mounting Position
Vertical: Base down

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

7-42 (4M)
Filing No. 8850

Supersedes GET-762

PRINTED IN U.S.A.

GENERAL ELECTRIC

Transmitting Tube GL-242-C - - Description and Rating

TECHNICAL INFORMATION

The GL-242-C is a three-electrode transmitting tube for use as an oscillator, radio-frequency amplifier, and audio-frequency amplifier or modulator (Class A or B).

GENERAL CHARACTERISTICS

ELECTRICAL

Filament Voltage	10	Volts
Filament Current	3.25	Amperes
Amplification Factor (I_b = .068)	12.5	
Grid-plate Transconductance	3600	Micromhos
Direct Interelectrode Capacitances		
Grid-plate	13	μμf
Grid-cathode	6.1	μμf
Plate-cathode	4.7	μμf

MECHANICAL

Base or Terminal Description	Jumbo 4-large Pin	
Net Weight (approx)	8	Ounces
Shipping Weight (approx)	4	Pounds
Installation and Operation	GEH-980	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS A A-F AMPLIFIER AND MODULATOR	Typical Operation		Maximum* Ratings	
Filament Voltage (d-c)		10		Volts
D-c Plate Voltage	1000	1250	1250	Volts
Plate Dissipation			85	Watts
D-c Grid Voltage	-56	-75		Volts
Peak Grid Swing (approx)	56	75		Volts
D-c Plate Current	.053	.060		Ampere
Plate Resistance	3800	3600		Ohms
Load Resistance	7600	9200		Ohms
Plate Power Output (5 per cent second harmonic)	12	20		Watts

CLASS B A-F POWER AMPLIFIER (TWO TUBES)

Filament Voltage (d-c)		10		Volts
D-c Plate Voltage	1000	1250	1250	Volts
Max Signal Plate Current (per tube)†			.150	Ampere
D-c Max Signal Plate Input (per tube)†			188	Watts
Plate Dissipation (per tube)†			100	Watts
D-c Grid Voltage	-72	-95		Volts
Peak A-f Grid Input Voltage	370	400		Volts
Zero Signal Plate Current	.020	.020		Ampere
Max Signal Plate Current	.300	.300		Ampere
Max Signal Plate Input†	300	375		Watts
Max Signal Driving Power (approx)	7.5	8		Watts
Effective Load (plate to plate)	6000	7600		Ohms
Max Signal Plate Power Output	165	200		Watts

CLASS B R-F POWER AMPLIFIER
(Carrier conditions per tube for use with a max modulation factor of 1.0)

Filament Voltage (d-c)		10		Volts
D-c Plate Voltage	1000	1250	1250	Volts
D-c Grid Voltage	-72	-95		Volts

CLASS B R-F POWER AMPLIFIER (CONT'D) (Carrier conditions per tube for use with a max modulation factor of 1.0)	Typical Operation		Maximum* Ratings	
D-c Plate Current	.150	.120	.150	Ampere
Plate Input			150	Watts
Plate Dissipation			100	Watts
Peak R-f Grid Input Voltage	135	160		Volts
Driving Power (approx)‡	12	12		Watts
Plate Power Output	50	50		Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED
(Carrier conditions per tube for use with a max modulation factor of 1.0)

Filament Voltage		10		Volts
D-c Plate Voltage	750	1000	1000	Volts
D-c Grid Voltage	-200	-260	-400	Volts
D-c Plate Current	.150	.150	.150	Ampere
D-c Grid Current (approx)	.035	.035	.050	Ampere
Plate Input			150	Watts
Plate Dissipation			67	Watts
Peak R-f Grid Input Voltage (approx)	350	410		Volts
Driving Power (approx)	12	14		Watts
Plate Power Output	65	100		

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
(Key-down conditions per tube without modulation)§

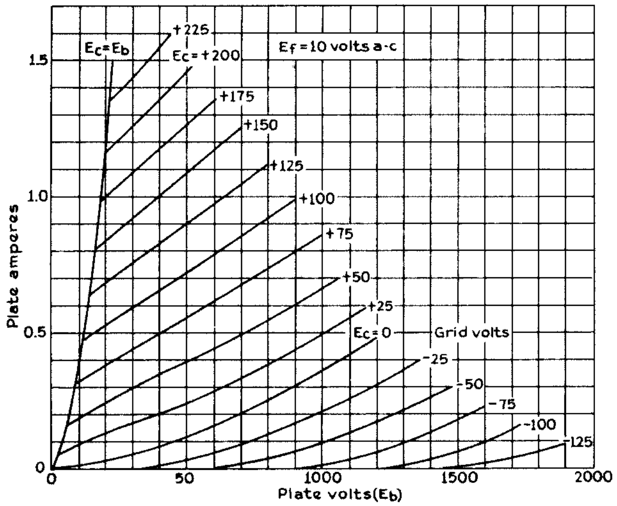
Filament Voltage		10		Volts
D-c Plate Voltage	1000	1250	1250	Volts
D-c Grid Voltage	-175	-225	-400	Volts
D-c Plate Current	.150	.150	.150	Ampere
D-c Grid Current (approx)	.020	.020	.050	Ampere
Plate Input			188	Watts
Plate Dissipation			100	Watts
Peak R-f Grid Input Voltage (approx)	315	375		Volts
Driving Power (approx)	6	7		Watts
Plate Power Output	100	130		Watts

† Averaged over any audio-frequency cycle.
‡ At crest of audio-frequency cycle.
§ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

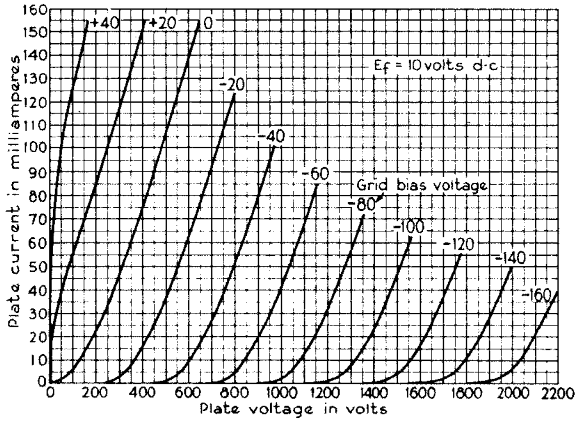
APPLICATION NOTES

* The GL-242-C can be operated at frequencies as high as 6 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 30 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

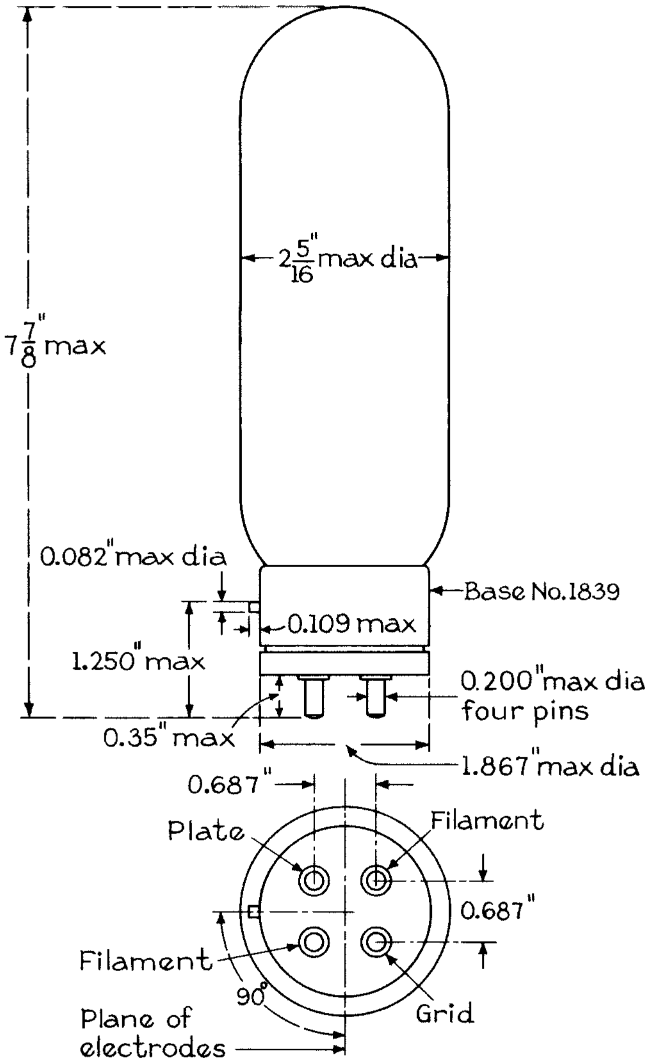
FREQUENCY, MEGACYCLES	6	15	30
MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT:			
Class B, R-f	100	85	70
Class C (Plate modulated (Unmodulated	100	75	50



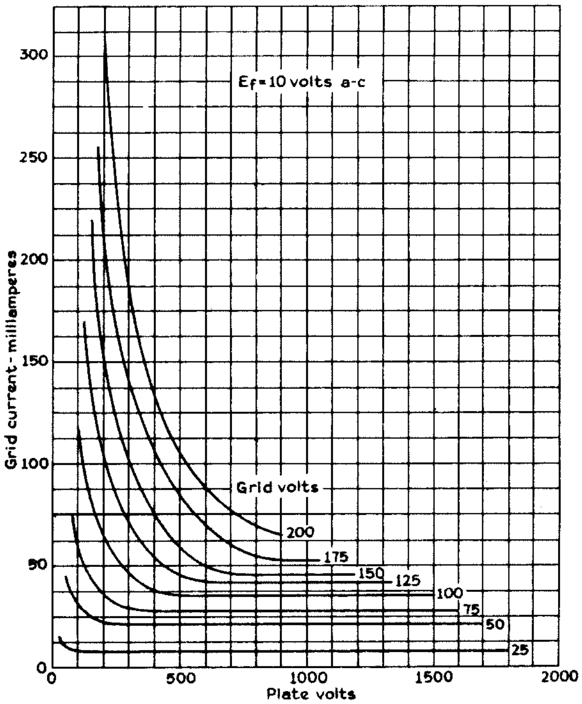
Average Plate Characteristics
for Transmitting Tube GL-242-C
K-6917437 4-11-40



Average Plate Characteristics
for Transmitting Tube GL-242-C
K-6917423 4-11-40



Outline Transmitting Tube GL-242-C
K-5302946 4-4-40



Average Characteristics for
Transmitting Tube GL-242-C
K-6917435 4-11-40

GENERAL ELECTRIC

SCHENECTADY, N.Y.

5-40 (2500)
Filing No. 8850

PRINTED IN U.S.A.

GENERAL ELECTRIC

Transmitting Tube GL-276-A - - Description and Rating

TECHNICAL INFORMATION

The GL-276-A is a three-electrode transmitting tube for use as an oscillator, radio-frequency amplifier, and audio-frequency amplifier or modulator (Class A or B).

GENERAL CHARACTERISTICS

ELECTRICAL

Filament Voltage	10	Volts
Filament Current	3.0	Amperes
Amplification Factor (I_b = .060)	12	
Grid-plate Transconductance	3600	Micromhos
Direct Interelectrode Capacitances		
Grid-plate	9	μμf
Grid-cathode	6	μμf
Plate-cathode	4	μμf

MECHANICAL

Base	Jumbo 4-large Pin	
Net Weight (approx)	8	Ounces
Shipping Weight (approx)	4	Pounds
Installation and Operation	GEH-980	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS A A-F AMPLIFIER AND MODULATOR	Typical Operation		Maximum* Ratings	
Filament Voltage, d-c		10		Volts
D-c Plate Voltage	1000	1250	1250	Volts
Plate Dissipation			85	Watts
D-c Grid Voltage	-56	-75		Volts
Peak Grid Swing (approx)	56	75		Volts
D-c Plate Current	.053	.060		Ampere
Plate Resistance	3800	3600		Ohms
Load Resistance	7600	9200		Ohms
Plate Power Output (5 per cent second harmonic)	12	20		Watts

CLASS B A-F POWER AMPLIFIER (TWO TUBES)

Filament Voltage		10		Volts
D-c Plate Voltage	1000	1250	1250	Volts
Max Signal Plate Current (per tube)†			.125	Ampere
D-c Max Signal Plate Input (per tube)†			156	Watts
Plate Dissipation (per tube)†			100	Watts
D-c Grid Voltage	-72	-95		Volts
Peak A-f Grid Input Voltage	320	390		Volts
Zero Signal Plate Current	.020	.020		Ampere
Maximum Signal Plate Current	.250	.250		Ampere
Maximum Signal Plate Input†	250	312		Watts
Max Signal Driving Power (approx)	7	7.5		Watts
Effective Load (plate to plate)	7000	9000		Ohms
Max Signal Plate Power Output	135	175		Watts

CLASS B R-F POWER AMPLIFIER
(Carrier conditions per tube for use with a max modulation factor of 1.0)

Filament Voltage, d-c		10		Volts
D-c Plate Voltage	1000	1250	1250	Volts
D-c Grid Voltage	-72	-95		Volts

CLASS B R-F POWER AMPLIFIER (CONT'D)
(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation		Maximum* Ratings	
D-c Plate Current	.125	.120	.125	Ampere
Plate Input			150	Watts
Plate Dissipation			100	Watts
Peak R-f Grid Input Voltage	125	145		Volts
Driving Power (approx)‡	10	10		Watts
Plate Power Output	42	50		Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED
(Carrier conditions per tube for use with a max modulation factor of 1.0)

Filament Voltage		10		Volts
D-c Plate Voltage	750	1000	1000	Volts
D-c Grid Voltage	-200	-260	-400	Volts
D-c Plate Current	.125	.125	.125	Ampere
D-c Grid Current (approx)	.035	.035	.050	Ampere
Plate Input			125	Watts
Plate Dissipation			67	Watts
Peak R-f Grid Input Voltage (approx)	325	385		Volts
Driving Power (approx)	12	14		Watts
Plate Power Output	55	85		Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
(Key-down conditions per tube without modulation)§

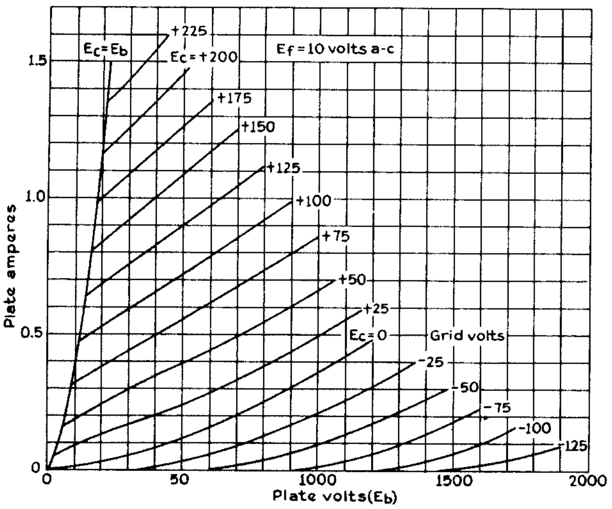
Filament Voltage		10		Volts
D-c Plate Voltage	1000	1250	1250	Volts
D-c Grid Voltage	-175	-225	-400	Volts
D-c Plate Current	.125	.125	.125	Ampere
D-c Grid Current (approx)	.020	.020	.050	Ampere
Plate Input			156	Watts
Plate Dissipation			100	Watts
Peak R-f Grid Input Voltage (approx)	290	350		Volts
Driving Power (approx)	6	7		Watts
Plate Power Output	85	100		Watts

† Averaged over any audio-frequency cycle.
‡ At crest of audio-frequency cycle.
§ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

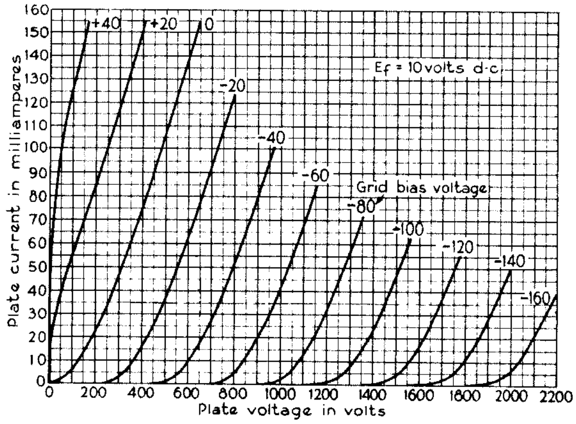
APPLICATION NOTES

* The GL-276-A can be operated at frequencies as high as 20 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 100 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

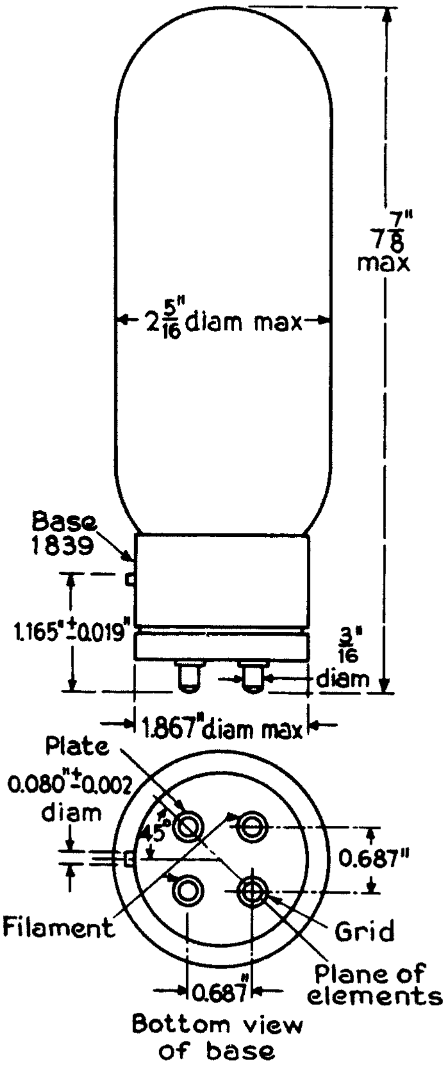
FREQUENCY	20	45	100
MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT:			
Class B, R-f	100	85	70
Class C (Plate modulated (Unmodulated	100	75	50



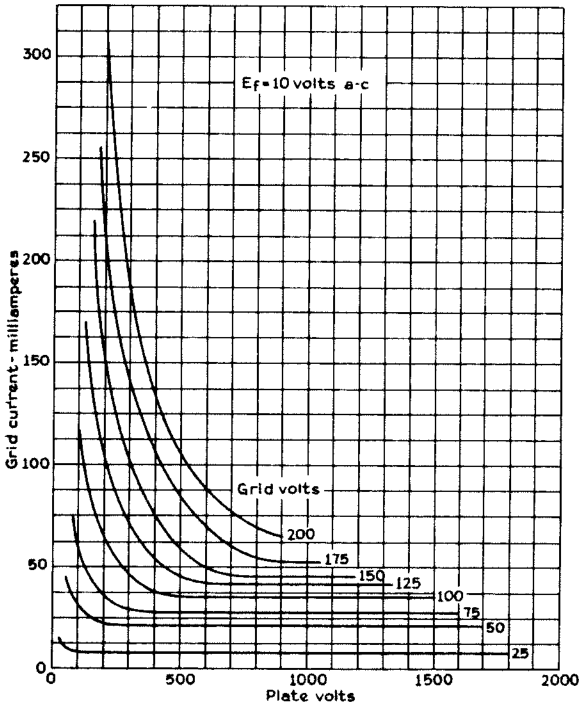
Average Plate Characteristics
for Transmitting Tube GL-276-A
K-6917437 4-11-40



Average Plate Characteristics
for Transmitting Tube GL-276-A
K-6917423 4-11-40



Outline Transmitting Tube GL-276-A
K-4909036 4-4-40



Average Characteristics for
Transmitting Tube GL-276-A
K-6917435 4-11-40

GENERAL ELECTRIC

SCHENECTADY, N.Y.

5-40 (2500)
Filing No. 8850

PRINTED IN U.S.A.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-800 - - Description and Rating

The 800 is a three-electrode transmitting tube designed for use as a radio-frequency amplifier or oscillator, particularly at the higher radio frequencies.

CHARACTERISTICS AND RATINGS

Filament Voltage (a-c or d-c)	7.5	Volts
Filament Current	3.25	Amperes
Amplification Factor	15	
Direct Interelectrode Capacitances:		
Grid-plate	2.5	μμf
Grid-filament	2.75	μμf
Plate-filament	2.75	μμf
Base	Medium 4-pin Bayonet	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

AS A-F POWER AMPLIFIER AND MODULATOR - CLASS B

D-c Plate Voltage	1250 max	Volts
Max Signal D-c Plate Current*	115 max	Milliamperes
Max Signal Plate Input*	85 max	Watts
Plate Dissipation*	35 max	Watts

Typical Operation:

Unless otherwise specified, values are for 2 tubes

D-c Plate Voltage	750	1000	1250	Volts
D-c Grid Voltage†	-40	-55	-70	Volts
Peak A-f Grid-to-grid Voltage	320	300	300	Volts
Zero Signal D-c Plate Current	26	28	30	Milliamperes
Max Signal D-c Plate Current	210	160	130	Milliamperes
Load Resistance (per tube)	1600	3125	5250	Ohms
Effective Load Resistance (plate-to-plate)	6400	12500	21000	Ohms
Max Signal Driving Power (approx)	6	4.4	3.4	Watts
Max Signal Power Output (approx)	90	100	106	Watts

AS R-F POWER AMPLIFIER - CLASS B TELEPHONY
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	1250 max	Volts
D-c Plate Current	45 max	Milliamperes
Plate Input	50 max	Watts
Plate Dissipation	35 max	Watts

Typical Operation:

D-c Plate Voltage	750	1000	Volts
D-c Grid Voltage†	-40	-55	Volts
Peak R-f Grid Voltage	160	170	Volts
D-c Plate Current	45	42	Milliamperes
D-c Grid Current (approx)**	2	2	Milliamperes
Driving Power (approx)**o	3.6	3.3	Watts
Power Output (approx)	10	14	Watts

AS PLATE-MODULATED R-F POWER AMPLIFIER - CLASS C TELEPHONY
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	1000 max	Volts
D-c Grid Voltage	-400 max	Volts
D-c Plate Current	80 max	Milliamperes
D-c Grid Current	25 max	Milliamperes
Plate Input	80 max	Watts
Plate Dissipation	23 max	Watts

Typical Operation:			
D-c Plate Voltage	750	1000	Volts
D-c Grid Voltage	-150	-200	Volts
Peak R-f Grid Voltage	275	325	Volts
D-c Plate Current	70	70	Milliamperes
D-c Grid Current (approx)**	15	15	Milliamperes
Grid Resistor	10000	13300	Ohms
Driving Power (approx)**	3	4	Watts
Power Output (approx)	35	50	Watts

AS R-F POWER AMPLIFIER AND OSCILLATOR - CLASS C TELEGRAPHY
Key-down conditions per tube without modulation‡‡

D-c Plate Voltage			1250 max	Volts
D-c Grid Voltage			-400 max	Volts
D-c Plate Current			80 max	Milliamperes
D-c Grid Current			25 max	Milliamperes
Plate Input			100 max	Watts
Plate Dissipation			35 max	Watts
Typical Operation:				
D-c Plate Voltage	750	1000	1250	Volts
D-c Grid Voltage	-100	-135	-175	Volts
Peak R-f Grid Voltage	225	260	300	Volts
D-c Plate Current	70	70	70	Milliamperes
D-c Grid Current (approx)**	15	15	15	Milliamperes
Grid Resistor	6700	9000	11700	Ohms
Driving Power (approx)**	2	3	4	Watts
Power Output (approx)	35	50	65	Watts

* Averaged over any audio-frequency cycle of sine-wave form.

† Grid voltages are given with respect to the midpoint of filament operated on alternating current. If direct current is used, each stated value of grid voltage should be decreased by 5 volts and the circuit returns made to the negative end of the filament.

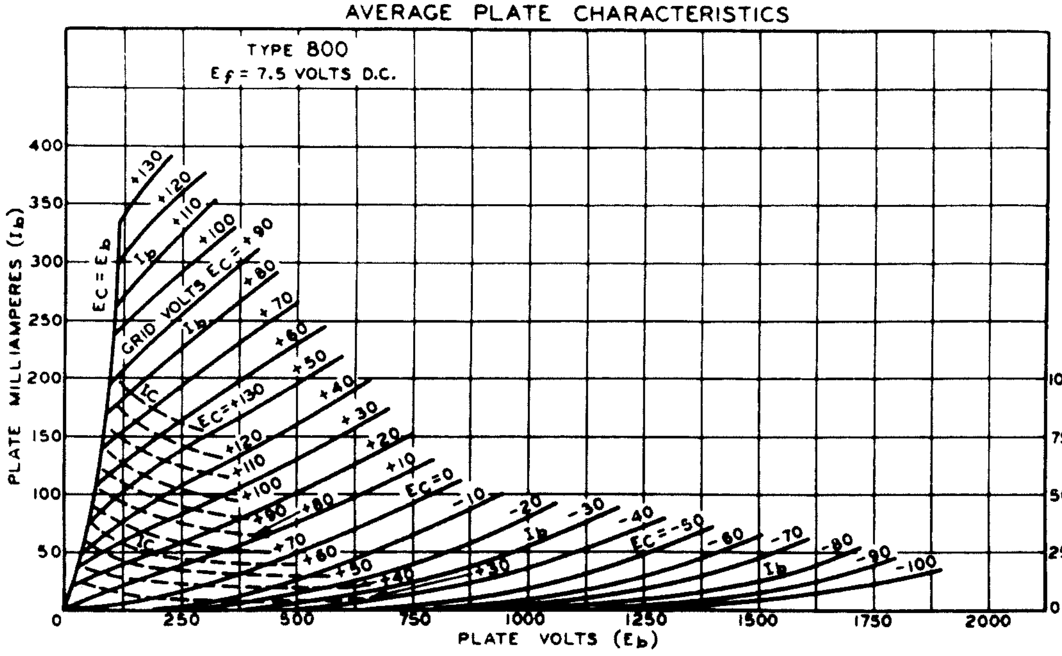
o At crest of audio-frequency cycle with modulation factor of 1.0.

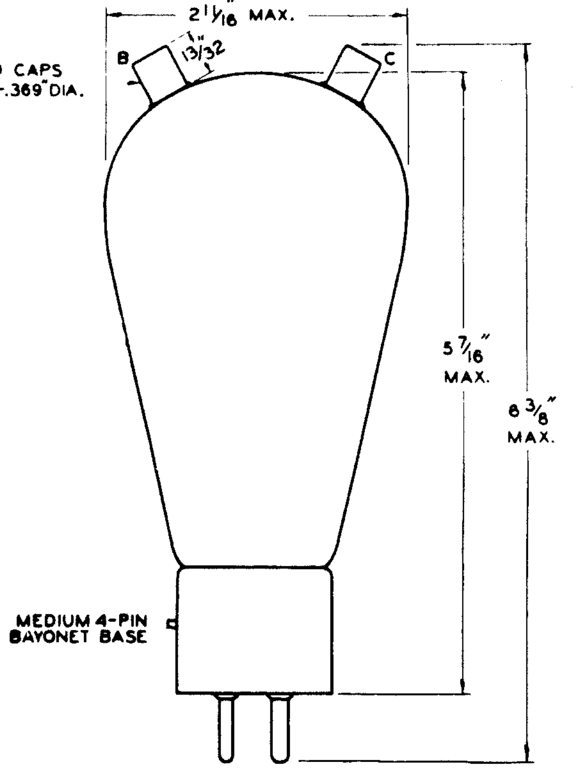
‡‡ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

** Subject to wide variations depending on the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits need less grid current and driving power, but plate-circuit efficiency is sacrificed. The driving stage should be capable of delivering considerably more than the required driving power.

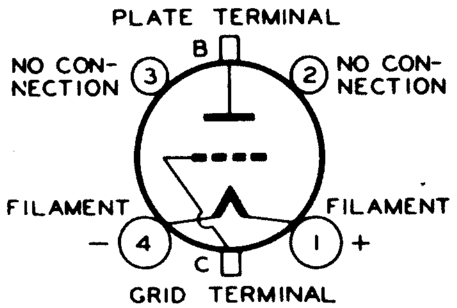
The maximum ratings apply only at frequencies below 60 megacycles. For operation at higher frequencies, adequate ventilation and normal ambient temperatures must be maintained, and the plate voltage must be reduced as indicated.

Frequency, Megacycles	60	100	180
Percentage of Maximum Rated Plate Voltage and Plate Input			
Class B	100	90	79
Class C, Plate-modulated	100	80	55
Class C, Telegraphy	100	80	55





Top View of Socket Connections



GENERAL ELECTRIC
SCHENECTADY, N.Y.

Supersedes GET-753

4-44 (8M)
Filing No 8850

PRINTED IN U.S.A.

GENERAL ELECTRIC

Transmitting Tube GL-801 - - Description and Rating

Technical Information

The GL-801 is a three-electrode high-vacuum tube for use as a radio-frequency amplifier and oscillator at high radio frequencies. It may also be used as an audio-frequency amplifier and modulator. The design of the tube is such that it may be operated at full ratings at frequencies as high as 60 megacycles.

These data are for reference only. For design information see the specifications.

CHARACTERISTICS AND RATINGS

Filament Voltage	7.5	Volts
Filament Current	1.25	Amperes
Amplification Factor (I_b = .030)	8	
Grid-plate Transconductance	1840	Micromhos
Direct Interelectrode Capacitances:		
Grid-plate	6	μμf
Grid-filament	4.5	μμf
Plate-filament	1.5	μμf
Base or Terminal Description	Medium 4-pin Ceramic, Bayonet	
Net Weight, approx	3	Ounces
Shipping Weight, approx	3	Pounds
Installation and Operation		GEH-980

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

	Typical Operating Conditions			Maximum Ratings	
CLASS A_1 A-F POWER AMPLIFIER AND MODULATOR					
D-c Plate Voltage	425	500	600	600	Volts
D-c Grid Voltage§	-40	-45	-55		Volts
D-c Plate Current	18	24	30		Ma
Plate Dissipation				20	Watts
Peak A-f Grid Voltage	35	40	50		Volts
Plate Resistance	5000	4600	4300		Ohms
Transconductance	1600	1725	1840		Micromhos
Load Resistance	10200	8000	7800		Ohms
U.P.O. 5% Second Harmonic	1.6	2.3	3.8		Watts
CLASS B A-F POWER AMPLIFIER (TWO TUBES)					
D-c Plate Voltage	400	500	600	600	Volts
Maximum Signal Plate Current (per tube)*				70	Milliamperes
D-c Maximum Signal Plate Input (per tube)*				42	Watts
Plate Dissipation (per tube)*				20	Watts
D-c Grid Voltage	-50	-60	-75		Volts
Peak A-f Grid Input Voltage	270	290	320		Volts
Zero Signal Plate Current	8	8	8		Milliamperes
Maximum Signal Plate Current	130	130	130		Milliamperes
Maximum Signal Driving Power (approx)	3	3	3		Watts
Effective Load (plate-to-plate)	6000	8000	10000		Ohms
Maximum Signal Plate Power Output	27	36	45		Watts

* Averaged over any audio-frequency cycle.

§ The d-c resistance in the grid circuit should not exceed 0.5 megohm with cathode bias, or 0.1 megohm with fixed bias.

	Typical Operating Conditions		Maximum Ratings	
CLASS B R-F POWER AMPLIFIER				
Carrier conditions per tube for use with a maximum modulation factor of 1.0				
D-c Plate Voltage	500	600	600	Volts
D-c Grid Voltage∆	-60	-75		Volts
D-c Plate Current	45	45	50	Milliamperes
Plate Input			30	Watts
Plate Dissipation			20	Watts
Peak R-f Grid Input Voltage	85	90		Volts
D-c Grid Current, approx**	.2	.2		Milliampere
Driving Power, approx†**	2.2	2.3		Watts
Plate Power Output	6	7.5		Watts
CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED				
Carrier conditions per tube for use with a maximum modulation factor of 1.0				
D-c Plate Voltage	400	500	500	Volts
D-c Grid Voltage∆◊	-150	-190	-200	Volts
	10000	12700		Ohms
D-c Plate Current	55	55	60	Milliamperes
D-c Grid Current, approx**	15	15	15	Milliamperes
Plate Input			30	Watts
Plate Dissipation			13.5	Watts
Peak R-f Grid Input Voltage, approx	260	300		Volts
Driving Power, approx**	4	4.5		Watts
Plate Power Output	14	18		Watts
CLASS C R-F POWER AMPLIFIER AND OSCILLATOR				
Key-down conditions per tube without modulation‡				
D-c Plate Voltage	500	600	600	Volts
D-c Grid Voltage∆π	-125	-150	-200	Volts
	8300	10000		Ohms
	1560	1875		Ohms
D-c Plate Current	65	65	70	Milliamperes
D-c Grid Current, approx	15	15	15	Milliamperes
Plate Input			42	Watts
Plate Dissipation			20	Watts
Peak R-f Grid Input Voltage, approx	235	260		Volts
Driving Power, approx	3.5	4		Watts
Plate Power Output	20	25		Watts

† At crest of audio-frequency cycle.

‡ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

∆ With a-c filament supply.

**Subject to wide variation depending on the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits need less grid current and driving power but plate circuit efficiency is sacrificed. The driving stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.

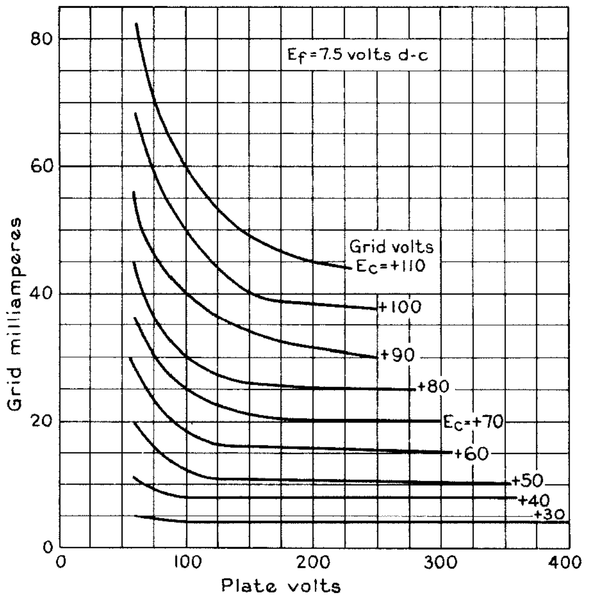
◊ Obtained by grid resistor of value shown, or by combination of grid resistor with either fixed supply or suitably by-passed cathode resistor.

π Obtained from fixed supply, by grid resistor (8300, 10000), or by cathode resistor (1560, 1875). When the 801 is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to maintain the plate current at a safe value. With a plate voltage of 600 volts, a fixed bias of at least 50 volts should be used.

The normal value of grid leak when the tube is used as an oscillator or r-f amplifier (Class C), is in the neighborhood of 10,000 ohms, although this may be replaced by a suitable fixed bias. If self-bias is used the cathode resistor should be approximately 2000 ohms.

The maximum ratings apply only at frequencies below 60 megacycles. For operation at higher frequencies adequate ventilation and normal ambient temperatures must be maintained, and the plate voltage must be reduced as indicated.

FREQUENCY	60	75	120	Mc
PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT				
Class B	100	93	78	
Class C, plate modulated	100	80	50	
Class C, telegraphy	100	80	50	



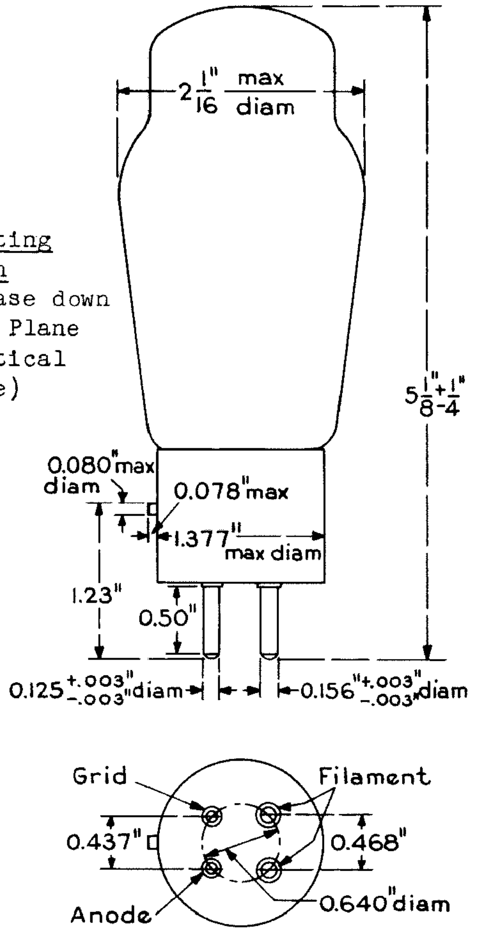
Typical Characteristics for Transmitting Tube GL-801

K-6917432 10-17-39

Tube Mounting Position

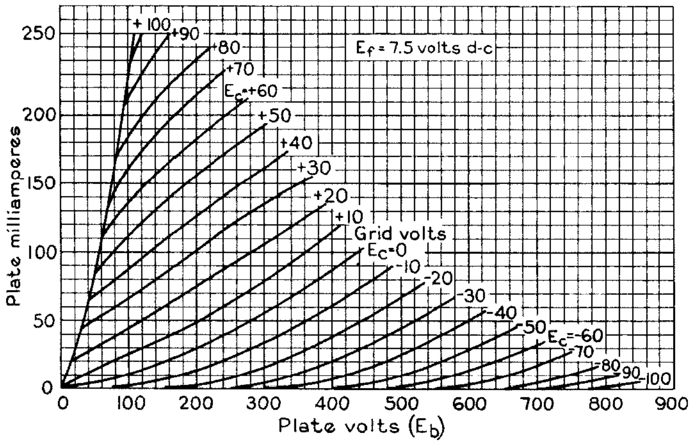
Vertical: Base down

Horizontal: Plane of plate vertical (on edge)



Outline Transmitting Tube GL-801

K-6912326 10-9-39



Average Plate Characteristics Transmitting Tube GL-801

K-6917431 10-17-39

GENERAL ELECTRIC
SCHENECTADY, N.Y.

Supersedes GET-761

2-42 (4M)
Filing No. 8850

PRINTED IN U.S.A.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-802 - - Description and Rating

The 802 is a pentode transmitting tube of the heater-cathode type having a maximum plate-dissipation rating of 13 watts (ICAS). The tube requires a driving power of only 1 watt or less, depending on the service in which it is used. The versatility of this pentode makes it well-suited for use as an r-f amplifier, frequency multiplier, oscillator, and suppressor-, grid- or plate-modulated amplifier. It may also be used as a Class A pentode amplifier or modulator. The plate connection is brought out of the tube through a separate seal at the top of the bulb to maintain low grid-plate capacitance. The suppressor and the special internal shield of this tube are connected to individual base pins. Neutralization is unnecessary in adequately shielded circuits. In r-f service, the 802 may be operated at maximum ratings at frequencies as high as 30 mc and at reduced ratings up to 110 mc.

R-F POWER AMPLIFIER PENTODE

Heater ⊖ Coated Unipotential Cathode		
Voltage	6.3	a-c or d-c volts
Current	0.9	amp
Transconductance for Plate Current of 20 ma	2250	umhos
Direct Interelectrode Capacitances		
Grid to Plate (with external shielding)	0.15	max μμf
Input	12	μμf
Output	8.5	μμf
Cap		Small Metal
Base		Medium 7-Pin Bayonet
Net Weight, approx		5 ounces
Shipping Weight, approx		3 lb
Installation and Operation		GEH-1116

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

A-F POWER AMPLIFIER AND MODULATOR - CLASS A

		CCS		ICAS	
D-c Plate Voltage		500 max		600 max	volts
D-c Screen Voltage (Grid #2)		250 max		250 max	volts
Plate Input		15 max		18 max	watts
Screen Input		3 max		3 max	watts
Typical Operation:					
D-c Plate Voltage	400	500	500	600	volts
Suppressor (Grid #3)	0*	0*	0*	40	volts
D-c Screen Voltage	250	175	225	250	volts
D-c Grid Voltage (Grid #1)◊	(-18	-10	-17	-18.5	volts
	(450	325	530	490	ohms
Peak A-f Grid Voltage	18	10	17	-18.5	volts
Internal Shield*	-	-	-	-	
D-c Plate Current	30	25	25	30	ma
D-c Screen Current	10	6	7	8	ma
Load Resistance	10000	18000	16000	13200	ohms
Total Har. Distortion	8	4	10	9	%
Power Output	5.5	4	6.5	7.6	watts

⊖ In circuits where the cathode is not directly connected to the heater, the potential difference between them should not exceed 100 volts.

* Connected to cathode at socket.

◊ Obtained from fixed supply or by cathode resistor of value shown. The d-c resistance in the grid circuit should not exceed 10000 ohms with fixed bias, or 50000 ohms with cathode bias.

R-F POWER AMPLIFIER - CLASS B TELEPHONY

Carrier conditions per tube for use with a max modulation factor of 1.0

	CCS	ICAS
D-c Plate Voltage	500 max	600 max volts
D-c Suppressor Voltage (Grid #3)	200 max	200 max volts
D-c Screen Voltage (Grid #2)	250 max	250 max volts
D-c Plate Current	30 max	30 max ma
Plate Input	15 max	18 max watts
Suppressor Input	2 max	2 max watts
Screen Input	4 max	4 max watts
Plate Dissipation	10 max	13 max watts

Typical Operation:				
D-c Plate Voltage	400	500	600	volts
Suppressor*†	-	-	-	
D-c Screen Voltage	150	200	225	volts
D-c Grid Voltage (Grid #1)	-22	-28	-30	volts
Peak R-f Grid Voltage	35	32	35	volts
Internal Shield*	-	-	-	
D-c Plate Current	25	25	30	ma
D-c Screen Current	6.5	7	8	ma
D-c Grid Current (approx)	1	0	0.5	ma
Driving Power (approx)o	0.5	0.18	0.18	watts
Power Output (approx)	2.75	3.5	5.3	watts

* Connected to cathode at socket.

† Applying a positive voltage of not more than 40 volts to the suppressor gives slightly increased output.

o At crest of a-f cycle with modulation factor of 1.0

SUPPRESSOR-MODULATED R-F POWER AMPLIFIER - CLASS C TELEPHONY

Carrier conditions per tube for use with a max modulation factor of 1.0.

	CCS	ICAS
D-c Plate Voltage	500 max	600 max volts
D-c Screen Voltage (Grid #2)	200 max	250 max volts
D-c Grid Voltage (Grid #1)	-200 max	-200 max volts
D-c Plate Current	30 max	30 max ma
D-c Grid Current	7.5 max	7.5 max ma
Plate Input	15 max	18 max watts
Screen Input	6 max	6 max watts
Plate Dissipation	10 max	13 max watts

Typical Operation					
D-c Plate Voltage	400	500	500	600	volts
D-c Suppressor Voltage (Grid #3)	-40	-53	-45	-45	volts
D-c Screen Voltage∆	8900	10700	10700	14500	ohms
D-c Grid Voltage+	(-85	-90	-90	-100	volts
	(11000	18000	20000	20000	ohms
Peak A-f Sup'r Voltage	40	53	65	65	volts
Peak R-f Grid Voltage	125	125	125	125	volts
Internal Shield*	-	-	-	-	
D-c Plate Current	18	20	22	30	ma
D-c Screen Current	28	28	28	24	ma
D-c Grid Current (approx)	7.5	5	4.5	5	ma
Driving Power (approx)	0.9	0.6	0.5	0.6	watts
Power Output (approx)	2	3	3.5	6.3	watts

* Connected to cathode at socket.

∆ Voltage taken from unmodulated plate-voltage supply through resistor of value shown.

\+ From fixed supply or grid resistor of value shown.

GRID-MODULATED R-F POWER AMPLIFIER - CLASS C TELEPHONY
Carrier conditions per tube for use with a max modulation factor of 1.0.

	CCS		ICAS	
D-c Plate voltage	500 max		600 max	volts
D-c Suppressor Voltage (Grid #3)	200 max		200 max	volts
D-c Screen Voltage (Grid #2)	250 max		250 max	volts
D-c Grid Voltage (Grid #1)	-200 max		-200 max	volts
D-c Plate Current	30 max		30 max	ma
Plate Input	15 max		18 max	watts
Suppressor Input	2 max		2 max	watts
Screen Input	4 max		4 max	watts
Plate Dissipation	10 max		13 max	watts
Typical Operation:				
D-c Plate Voltage	400	500	600	volts
Suppressor*†	-	-	-	
D-c Screen Voltage	150	200	250	volts
D-c Grid Voltage	-105	-130	-130	volts
Peak A-f Grid Voltage	40	50	50	volts
Peak R-f Grid Voltage	125	145	145	volts
Internal Shield*	-	-	-	
D-c Plate Current	25	25	30	ma
D-c Screen Current	7.5	8	8	ma
D-c Grid Current (approx)	2	1	1	ma
Driving Power (approx)○	1	0.8	0.8	watt
Power Output (approx)	3	4	6	watts

* Connected to cathode at socket.
† Applying a positive voltage of not more than 40 volts to the suppressor gives slightly increased output.
○ At crest of a-f cycle with modulation factor of 1.0.

PLATE-MODULATED R-F POWER AMPLIFIER - CLASS C TELEPHONY
Pentode Connection
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	400 max	500 max	volts
D-c Suppressor Voltage (Grid #3)	200 max	200 max	volts
D-c Screen Voltage (Grid #2)	200 max	250 max	volts
D-c Grid Voltage (Grid #1)	-200 max	-200 max	volts
D-c Plate Current	40 max	40 max	ma
D-c Grid Current	7.5 max	7.5 max	ma
Plate Input	16 max	20 max	watts
Suppressor Input	2 max	2 max	watts
Screen Input	4 max	4 max	watts
Plate Dissipation	6.7 max	8 max	watts
Typical Operation			
D-c Plate Voltage	400	500	volts
D-c Suppressor Voltage	40	40	volts
D-c Screen Voltage π	(195	245	volts
	(11500	16300	ohms
D-c Grid Voltage ‡	(-40	-40	volts
	(27000	27000	ohms
Peak R-f Grid Voltage	55	55	volts
Internal Shield*	-	-	
D-c Plate Current	35	40	ma
D-c Screen Current	17	15	ma
D-c Grid Current (approx)	1.5	1.5	ma
Driving Power (approx)	0.1	0.1	watt
Power Output (approx)	8	12	watts

‡ Obtained by grid resistor of value shown or by partial self-bias methods.
π From modulated fixed supply or modulated plate-voltage supply through resistor of value shown.

PLATE-MODULATED R-F POWER AMPLIFIER - CLASS C TELEPHONY

Tetrode Connection - Grids #2 and #3 tied together

Carrier conditions per tube for use with a max modulation factor of 1.0

	CCS	ICAS	
D-c Plate Voltage	400 max	500 max	volts
D-c Screen Voltage (Grids #2 and #3)	200 max	200 max	volts
D-c Grid Voltage (Grid #1)	-200 max	-200 max	volts
D-c Plate Current	40 max	40 max	ma
D-c Grid Current	7.5 max	7.5 max	ma
Plate Input	16 max	20 max	watts
Screen Input	6 max	6 max	watts
Plate Dissipation	6.7 max	8 max	watts
Typical Operation:			
D-c Plate Voltage	400	500	volts
D-c Screen Voltage∅	(85	195	volts
	(15000	18000	ohms
D-c Grid Voltage§	-120	-120	volts
	(20000	20000	ohms
Peak R-f Grid Voltage	160	160	volts
Internal Shield*	-	-	
D-c Plate Current	35	40	ma
D-c Screen Current	21	17	ma
D-c Grid Current (approx)	6	6	ma
Driving Power (approx)	0.9	0.9	watt
Power Output (approx)	8	12	watts

∅ Preferably from unmodulated plate-voltage supply through resistor of value shown.

§ Obtained by grid resistor of value shown or by partial self-bias methods.

* Connected to cathode at socket.

R-F POWER AMPLIFIER AND OSCILLATOR - CLASS C TELEGRAPHY

Pentode Connection

Key down conditions per tube without modulation¶

D-c Plate Voltage		500 max		600 max	volts
D-c Suppressor Voltage (Grid #3)		200 max		200 max	volts
D-c Screen Voltage (Grid #2)		250 max		250 max	volts
D-c Grid Voltage (Grid #1)		-200 max		-200 max	volts
D-c Plate Current		60 max		60 max	ma
D-c Grid Current		7.5 max		7.5 max	ma
Plate Input		25 max		33 max	ma
Suppressor Input		2 max		2 max	watts
Screen Input		6 max		6 max	watts
Plate Dissipation		10 max		13 max	watts
Typical Operation:					
D-c Plate Voltage	400	500	500	600	volts
D-c Suppressor Voltage	0	0	40	40	volts
D-c Screen Voltage⊗	(200	200	250	250	volts
	(8000	13600	20800	22000	ohms
	(-100	-100	-100	-120	volts
D-c Grid Voltage ΔΔ	(14000	17000	50000	42000	ohms
	(1300	1370	1700	1620	ohms
Peak R-f Grid Voltage	155	155	155	165	volts
Internal Shield*	-	-	-	-	
D-c Plate Current	45	45	45	55	ma
D-c Screen Current	25	22	12	16	ma
D-c Grid Current (approx)	7	6	2	2.4	ma
Driving Power (approx)	1.1	0.9	0.25	0.3	watt
Power Output (approx)	10	14	16	23	watts

Notes for above on following page.

R-F POWER AMPLIFIER AND OSCILLATOR - CLASS C TELEGRAPHY
Tetrode Connection - Grids #2 and #3 tied together
Key-down conditions per tube without modulation¶

	CCS		ICAS	
D-c Plate Voltage	500 max		600 max	volts
D-c Screen Voltage (Grids #2 and #3)	200 max		200 max	volts
D-c Grid Voltage (Grid #1)	-200 max		-200 max	volts
D-c Plate Current	60 max		60 max	ma
D-c Grid Current	7.5 max		7.5 max	ma
Plate Input	25 max		33 max	watts
Screen Input	6 max		6 max	watts
Plate Dissipation	10 max		13 max	watts
Typical Operation:				
D-c Plate Voltage	400	500	600	volts
D-c Screen Voltage◊◊	(100	100	150	volts
	(20000	27000	30000	ohms
	-60	-60	-60	volts
D-c Grid Voltage≠	8600	10000	10000	ohms
	1000	1000	860	ohms
Peak R-f Grid Voltage	90	90	90	volts
Internal Shield*	-	-	-	
D-c Plate Current	45	45	55	ma
D-c Screen Current	15	15	15	ma
D-c Grid Current (approx)	7	6	6	ma
Driving Power (approx)	0.7	0.5	0.5	watt
Power Output (approx)	10	12	23	watts

ΔΔ Obtained from grid resistor (14000, 17000, 50000, 42000), by cathode resistor (1300, 1370, 1700, 1620) or from fixed supply.

≠ Obtained by grid resistor (8600, 10000), by cathode resistor (1000, 860), or from fixed supply.

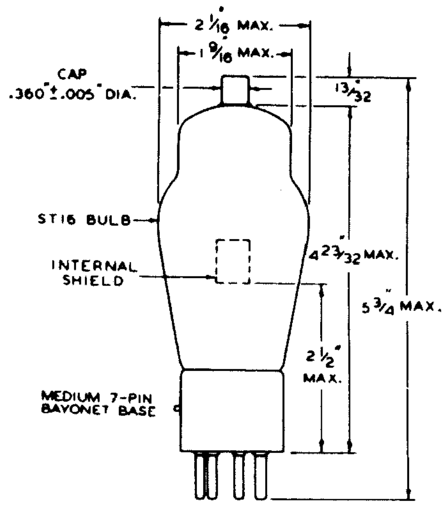
¶ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

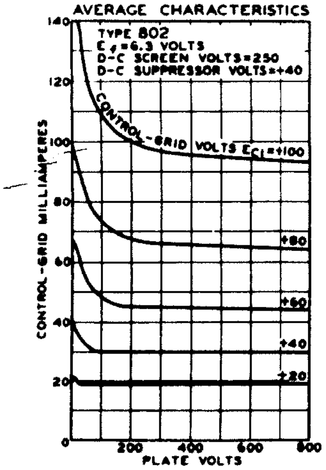
◊◊ From fixed supply or plate-voltage supply through resistor of value shown. Under key-up conditions, max screen voltage should not exceed 500 volts. Series screen resistor of value shown should not be used except where the 802 is employed as a buffer amplifier and is not keyed.

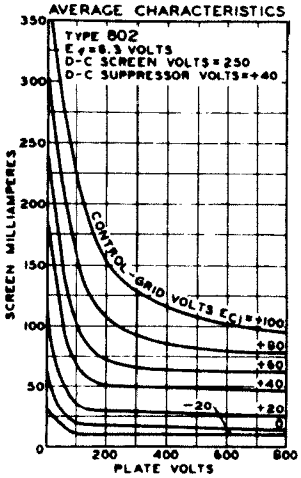
* Connected to cathode at socket.

The GL-802 can be operated at frequencies as high as 30 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 110 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

Frequency, megacycles	30	55	100
Maximum Permissible Percentage of Maximum Rated Plate Voltage and Plate Input			
Telephony, Class B	100	88	76
Class C, Grid-Mod	100	88	76
Class C, Sup'r-Mod	100	88	76
Class C, Plate-Mod	100	77	55
Telegraphy, Class C	100	77	55

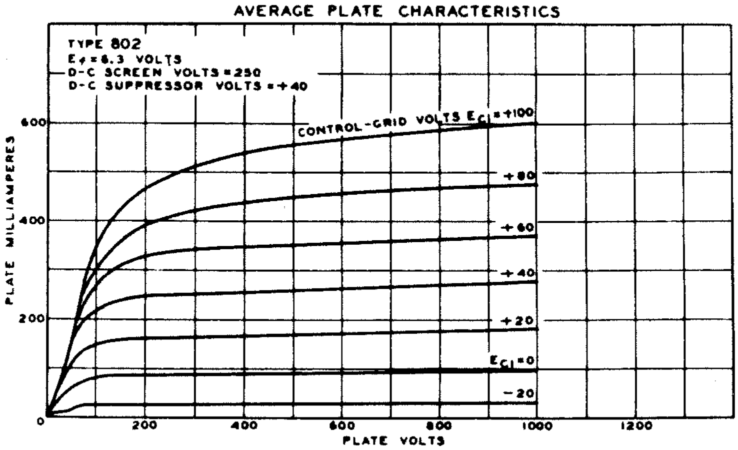




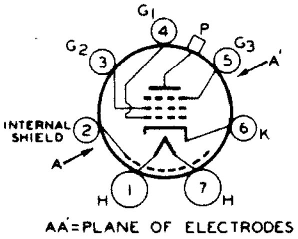


Tube Mounting Position

Vertical or Horizontal



Bottom View of Socket Connections



GENERAL ELECTRIC

SCHENECTADY, N.Y.

4-44 (8M)
Filing No. 8850

Supe *Supersedes GET-760A*

PRINTED IN U.S.A.

GENERAL ELECTRIC

Transmitting Tube GL-803 - - Description and Rating

The GL-803 is a pentode transmitting tube of the thoriated-tungsten filament type for use as an r-f amplifier, frequency multiplier, oscillator, and suppressor-, grid-, or plate-modulated amplifier. The tube has a maximum plate dissipation of 125 watts. The plate connection is brought out through a separate seal at the top of the bulb to maintain low grid-plate capacitance. Neutralization is unnecessary in adequately shielded circuits. The suppressor is connected to its individual base pin. The 803 may be operated at maximum ratings in all classes of service at frequencies as high as 20 megacycles.

CHARACTERISTICS AND RATINGS

These data are for reference only. For design information see the specifications.

Filament Voltage, a-c or d-c	10.0	Volts
Filament Current	5	Amperes
Transconductance, for plate current of 62.5 ma	4000	Micromhos
Direct Interelectrode Capacitances:		
Grid-plate, with external shielding	0.15 max	μμf
Input	17.5	μμf
Output	29	μμf
Cap	Medium Metal	
Base	Giant 5-pin Ceramic, Bayonet	
Net Weight, approx	10	Ounces
Shipping Weight, approx	3	Pounds
Installation and Operation	GEH-1115	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

AS R-F POWER AMPLIFIER PENTODE - CLASS B TELEPHONY
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	1250	1500	2000	2000	Volts
D-c Suppressor Voltage, grid No. 3	40	40	40	500	Volts
D-c Screen Voltage, grid No. 2	500	550	600	600	Volts
D-c Grid Voltage, grid No. 1*	-30	-35	-40		Volts
Peak R-f Grid Voltage	90	70	55		Volts
D-c Plate Current	130	110	80	160	Milliamperes
Plate Input				180	Watts
Suppressor Input				10	Watts
Screen Input				20	Watts
Plate Dissipation				125	Watts
D-c Screen Current	33	30	20		Milliamperes
D-c Grid Current, approx	8	5	3		Milliamperes
Driving Power, approx†	4.5	3	1.5		Watts
Power Output, approx	52	53	53		Watts

AS SUPPRESSOR-MODULATED R-F POWER AMPLIFIER - CLASS C TELEPHONY
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	1250	1500	2000	2000	Volts
D-c Suppressor Voltage, grid No. 3	-70	-90	-110		Volts
D-c Grid Voltage				-500	Volts
From a fixed supply of	-110	-100	-100		Volts
From a grid resistor of	5000	5000	7000		Ohms
Peak R-f Grid Voltage	200	190	170		Volts
Peak A-f Suppressor Voltage	110	130	150		Volts
D-c Plate Current	100	100	80	110	Milliamperes

D-c Screen Current	70	70	48		Milliamperes
D-c Grid Current, approx	22	20	15	50	Milliamperes
Screen Resistor	13000	17000	35000		Ohms
Driving Power, approx	4	3.5	2.5		Watts
Power Output, approx	40	50	53		Watts
D-c Screen Voltage, grid No. 2				600	Volts
Plate Input				180	Watts
Screen Input				30	Watts
Plate Dissipation				125	Watts

AS GRID-MODULATED R-F POWER AMPLIFIER PENTODE - CLASS C TELEPHONY
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	1250	1500	2000	2000	Volts
D-c Suppressor Voltage, grid No. 3	40	40	40	500	Volts
D-c Screen Voltage, grid No. 2	500	550	600	600	Volts
D-c Grid Voltage, grid No. 1	-100	-90	-80	-500	Volts
Peak R-f Grid Voltage	160	130	100		Volts
Peak A-f Grid Voltage	75	65	50		Volts
D-c Plate Current	130	110	80	160	Milliamperes
D-c Screen Current	30	25	20		Milliamperes
D-c Grid Current, approx	8	6	4		Milliamperes
Driving Power, approx†	4	3	2		Watts
Power Output, approx	52	53	53		Watts
Plate Input				180	Watts
Suppressor Input				10	Watts
Screen Input				20	Watts
Plate Dissipation				125	Watts

AS PLATE-MODULATED R-F POWER AMPLIFIER PENTODE - CLASS C TELEPHONY
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	1250	1600	1600	Volts
D-c Suppressor Voltage, grid No. 3	100	100	500	Volts
D-c Screen Voltage, grid No. 2	400	500	500	Volts
D-c Grid Voltage, grid No. 1			-500	Volts
From a fixed supply of	-80	-80		Volts
From a grid resistor of	4000	4000		Ohms
Peak R-f Grid Voltage	180	180		Volts
D-c Plate Current	150	150	160	Milliamperes
D-c Screen Current	55	55		Milliamperes
D-c Grid Current, approx	20	20	50	Milliamperes
Screen Resistor‡	16000	20000		Ohms
Driving Power, approx	4	4		Watts
Power Output, approx	125	155		Watts
Plate Input			250	Watts
Suppressor Input			10	Watts
Screen Input			20	Watts
Plate Dissipation			85	Watts

AS PLATE-MODULATED R-F POWER AMPLIFIER TETRODE - CLASS C TELEPHONY
Carrier conditions per tube for use with a max modulation factor of 1.0
Grids No. 2 and No. 3 connected together

D-c Plate Voltage	1250	1600	1600	Volts
D-c Screen Voltage, grids No. 2 and 3	130	130	500	Volts
D-c Grid Voltage, grid No. 1			-500	Volts
From a fixed supply of	-180	-180		Volts
From a grid resistor of	4000	4000		Ohms
Peak R-f Grid Voltage	305	320		Volts
D-c Plate Current	150	150	160	Milliamperes
D-c Screen Current	75	75		Milliamperes
D-c Grid Current, approx	45	45	50	Milliamperes
Screen Resistor§	15000	20000		Ohms
Driving Power, approx	15	15		Watts

Power Output, approx		125	155		Watts
Plate Input				250	Watts
Screen Input				30	Watts
Plate Dissipation				85	Watts

AS R-F POWER AMPLIFIER AND OSCILLATOR PENTODE - CLASS C TELEGRAPHY
Key-down conditions per tube without modulation◊

D-c Plate Voltage	1250	1500	2000	2000	Volts
D-c Suppressor Voltage, grid No. 3	40	40	40	500	Volts
D-c Screen Voltage, grid No. 2	500	500	500	600	Volts
D-c Grid Voltage, grid No. 1				-500	Volts
From a fixed supply of	-90	-90	-90		Volts
From a cathode resistor of	415	415	415		Ohms
From a grid resistor of	7500	7500	7500		Ohms
Peak R-f Grid Voltage	175	175	175		Volts
D-c Plate Current	160	160	160	175	Milliamperes
D-c Screen Current	45	45	45		Milliamperes
D-c Grid Current, approx	12	12	12	50	Milliamperes
Screen Resistor		Not recommended			
Driving Power, approx	2	2	2		Watts
Power Output, approx	130	160	210		Watts
Plate Input				350	Watts
Suppressor Input				10	Watts
Screen Input				30	Watts
Plate Dissipation				125	Watts

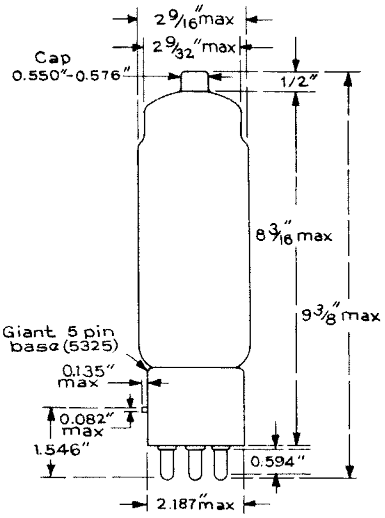
AS R-F POWER AMPLIFIER AND OSCILLATOR TETRODE - CLASS C TELEGRAPHY
Key-down conditions per tube without modulation◊
Grids No. 2 and No. 3 connected together

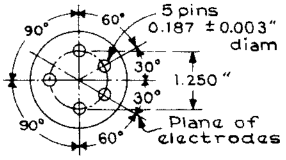
D-c Plate Voltage	1250	1500	2000	2000	Volts
D-c Screen Voltage, grids No. 2 and 3	150	150	150	600	Volts
D-c Grid Voltage, grid No. 1				-500	Volts
From a fixed supply of	-90	-90	-90		Volts
From a cathode resistor of	445	445	445		Ohms
From a grid resistor of	3500	3500	3500		Ohms
Peak R-f Grid Voltage	190	190	190		Volts
D-c Plate Current	160	160	160	175	Milliamperes
D-c Screen Current	15	15	15		Milliamperes
D-c Grid Current, approx	28	27	26	50	Milliamperes
Screen Resistor		Not recommended			
Driving Power, approx	4.6	4.4	4.4		Watts
Power Output, approx	130	160	210		Watts
Plate Input				350	Watts
Screen Input				30	Watts
Plate Dissipation				125	Watts

† At crest of audio-frequency cycle with modulation factor of 1.0.
* Grid voltages are given with respect to the midpoint of filament operated on alternating current. If direct current is used, each stated value of grid voltage should be decreased by one-half the filament voltage and the circuit returns connected to the negative end of the filament.
‡ Connected to modulated plate-voltage supply.
§ Connected to unmodulated plate-voltage supply.
◊ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

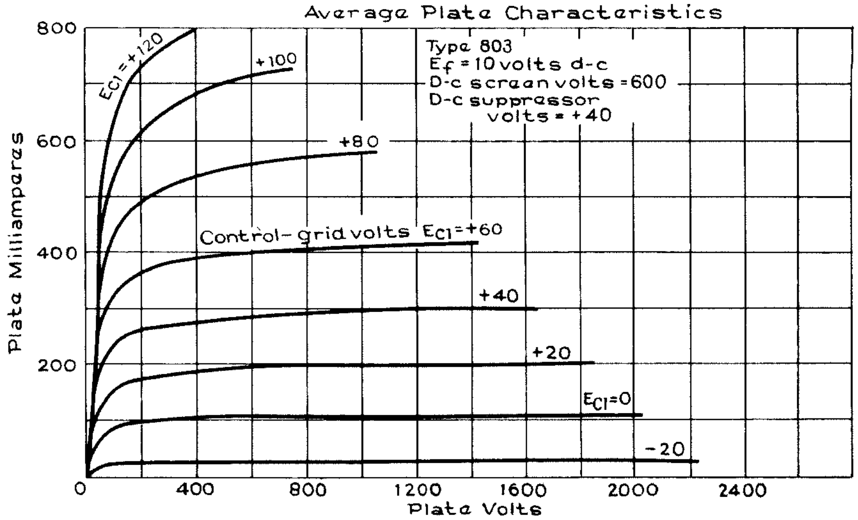
The maximum ratings apply only at frequencies below 20 megacycles. For operation at higher frequencies adequate ventilation and normal ambient temperatures must be maintained, and the plate voltage must be reduced as indicated.

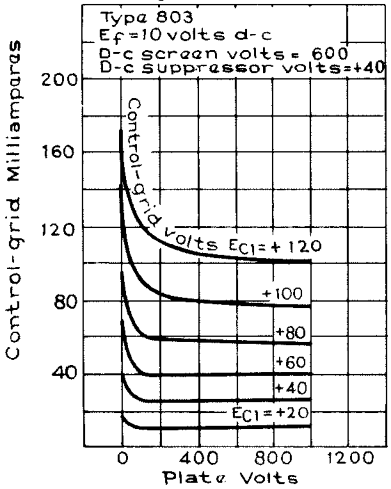
Frequency, Megacycles	20	40	60
Percentage of Maximum Rated Plate Voltage and Plate Input			
Class B, R-f	100	86	80
Class C, Grid- or Suppressor-mod.	100	86	80
Class C, Plate-mod.	100	77	60
Class C, Telegraphy	100	77	60

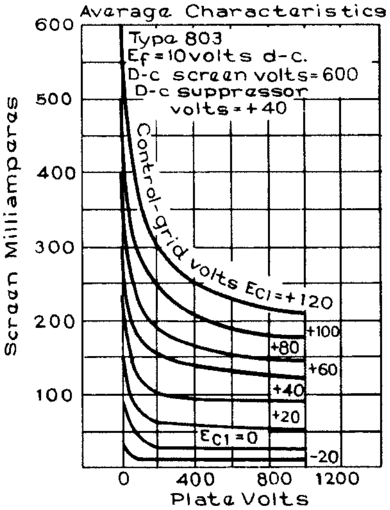




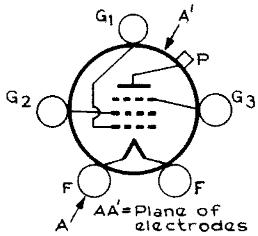
Bottom view of base







Bottom view of socket connections



F = Filament
G_1 = Grid
G_2 = Screen
G_3 = Suppressor
P = Plate

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

10-43 (7M)
Filing No. 8850

Supersedes GET-759

PRINTED IN U.S.A.

GENERAL ELECTRIC

Transmitting Tube GL-805 - - Description and Rating

TECHNICAL INFORMATION

The 805 is a high-mu, three-electrode tube for use as an r-f amplifier, Class B modulator and oscillator. Valuable characteristics of this tube are high-power output at relatively low plate voltage and unusually low grid-bias requirements.

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Filament Voltage	10.0	Volts
Filament Current	3.25	Amperes
Direct Interelectrode Capacitances:		
Grid-plate	6.5	μμf
Input	8.5	μμf
Output	10.5	μμf
Base or Terminal Description	Jumbo 4-large Pin	
Frequency for Maximum Ratings	30	Megacycles
Type of Cooling	Natural Ventilation	
Net Weight (approx)	8	Ounces
Installation and Operation	GEH-980	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B A-F POWER AMPLIFIER (TWO TUBES):

D-c Plate Voltage	1250	1500	1500	Volts
Maximum Signal Plate Current (per tube)*			210	Milliamperes
D-c Maximum Signal Plate Input (per tube)*			315	Watts
Plate Dissipation (per tube)*			125	Watts
D-c Grid Voltage		-16		Volts
Peak A-f Grid Input Voltage	235	280		Volts
Zero Signal Plate Current	148	84		Milliamperes
Maximum Signal Plate Current	400	400		Milliamperes
Maximum Signal Plate Input*	500	600		Watts
Maximum Signal Driving Power (approx)	6	7		Watts
Effective Load (plate-to-plate)	6700	8200		Ohms
Maximum Signal Plate Power Output	300	370		Watts

CLASS B R-F POWER AMPLIFIER
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	1250	1500	1500	Volts
D-c Grid Voltage		-10		Volts
D-c Plate Current	135	115	150	Milliamperes
Plate Input			185	Watts
Plate Dissipation			125	Watts
Peak R-f Grid Input Voltage	75	70		Volts
D-c Grid Current (approx)	15	15		Milliamperes
Driving Power (approx)**	11	7.5		Watts
Plate Power Output	55	57.5		Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	1000	1250	1250	Volts
D-c Grid Voltage	-155	-160	-500	Volts
D-c Plate Current	160	160	175	Milliamperes
D-c Grid Current (approx)	60	60	70	Milliamperes
Plate Input			220	Watts
Plate Dissipation			85	Watts
Peak R-f Grid Input Voltage (approx)	295	300		Volts
Driving Power (approx)	16	16		Watts
Plate Power Output	110	140		Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR

Key-down conditions per tube without modulation†

D-c Plate Voltage	1000	1250	1500	1500	Volts
D-c Grid Voltage	-95	-100	-105	-500	Volts
D-c Plate Current	200	200	200	210	Milliamperes
D-c Grid Current (approx)	40	40	40	70	Milliamperes
Plate Input				315	Watts
Plate Dissipation				125	Watts
Peak R-f Grid Input Voltage (approx)	225	230	235		Volts
Driving Power (approx)	8.5	8.5	8.5		Watts
Plate Power Output	130	170	215		Watts

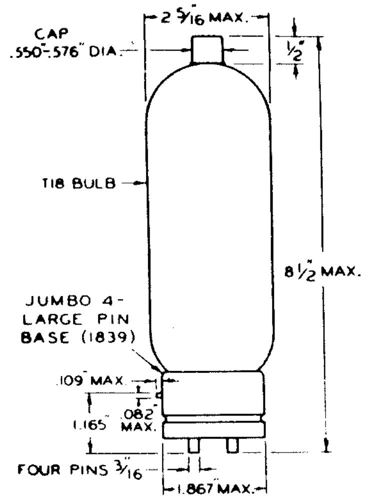
* Averaged over any audio-frequency cycle.

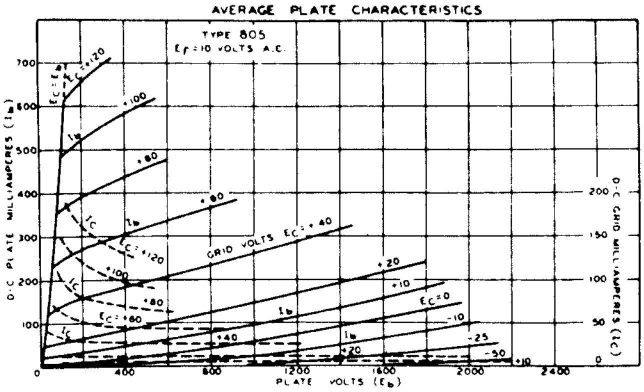
** At crest of audio-frequency cycle.

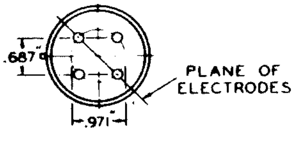
† Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

GL-805 can be operated at maximum ratings in all classes of service at frequencies as high as 30 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown under CHARACTERISTICS). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 80 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

FREQUENCY	30	45	80	Mc
Maximum Permissible Percentage of Maximum Rated Plate Voltage and Plate Input:				
Class B Telephony	100	90	77	Per Cent
Class C (Telephony, plate-modulated / Telegraphy)	100	82	55	Per Cent

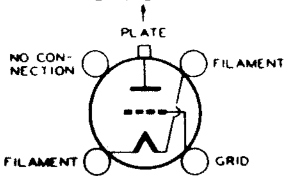






BOTTOM VIEW OF BASE

Top View of Socket Connections



GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

11-41 (3M)

Filing No. 8850

Supersedes GET-921

PRINTED IN U.S.A.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-806--Description and Rating

The 806 is a three-electrode transmitting triode designed for use as a radio-frequency amplifier, oscillator, and Class B modulator. Maximum plate dissipation for Class C telegraph and Class B services is 225 watts (ICAS). The tantalum plate of this tube totally encloses the other electrodes and thus conserves power by eliminating loss from bulb bombardment and stray electrons. At 30 mc this construction provides the user with more than 75 watts of additional power per tube. The 806 may be operated at maximum ratings at frequencies as high as 100 mc. In Class B modulator service (ICAS), two 806's are capable of modulating 100 per cent an r-f amplifier having an input of 2240 watts. Plate and grid connections, brought out to the top and side of the bulb respectively, provide low-tube capacitances and high insulation.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Filament Voltage (a-c or d-c)	5.0 Volts
Filament Current	9.5 Amperes
Amplification Factor	12.6
Direct Interelectrode Capacitances:	
Grid-plate	4.0 uuf
Grid-filament	5.5 uuf
Plate-filament	0.4 uuf
Cooling	Air †

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B A-F POWER AMPLIFIER AND MODULATOR, TWO TUBES

Filament Voltage, a-c or d-c 5.0 Volts

	Typical Operation CCS		Typical Operation ICAS	Maximum Ratings CCS	Maximum Ratings ICAS	
D-c Plate Voltage	2000	3000	3300	3000	3300	Volts
Max Signal D-c Plate Current*				200	250	Milliamperes
Max Signal Plate Input*				500	825	Watts
Plate Dissipation*				150	225	Watts
D-c Grid Voltage	-140	-230	-240			Volts
Peak A-f Grid-to-grid Voltage	660	770	930			Volts
Zero Signal D-c Plate Current	80	50	80			Milliamperes
Max Signal D-c Plate Current	390	330	475			Milliamperes
Load Resistance, per tube	4500	5200	4000			Ohms
Effective Load Resistance, Plate-to-plate	18000	20800	16000			Ohms
Max Signal Driving Power, approx	19	15	35			Watts
Max Signal Plate Power Output, approx	535	700	1120			Watts

	Typical Operation				Maximum Ratings		

CLASS B R-F POWER AMPLIFIER - Telephony
Carrier conditions per tube for use with a max modulation factor of 1.0

	CCS		ICAS	CCS	ICAS	
D-c Plate Voltage	2000	3000	3300	3000	3300	Volts
D-c Grid Voltage	-150	-240	-280			Volts
D-c Plate Current	110	70	102	150	150	Milliamperes
Plate Input				225	338	Watts
Plate Dissipation				150	225	Watts
Peak R-f Grid Voltage	180	200	290			Volts
D-c Grid Current, approx	1	0	0			Milliamperes
Driving Power, approx °	8	5	10.3			Watts
Power Output, approx	70	70	115			Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR, PLATE MODULATED
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	2000	2500	3000	2500	3000	Volts
D-c Grid Voltage‡	-500	-600	-670	-1000	-1000	Volts
	12500	15000	25000			Ohms
D-c Plate Current	195	195	195	200	200	Milliamperes
D-c Grid Current, approx**	40	40	27	50	50	Milliamperes
Plate Input				500	600	Watts
Plate Dissipation				110	150	Watts
Peak R-f Grid Voltage	790	890	970			Volts
Driving Power, approx**	28	32	24			Watts
Power Output, approx	300	390	460			Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - Telegraphy
Key down conditions per tube without modulationπ

D-c Plate Voltage	2000	2500	3000	3300	3000	3300	Volts
D-c Grid Voltage§	-400	-500	-600	-600	-1000	-1000	Volts
	16000	20000	24000	15000			Ohms
	1800	2300	2700	1730			Ohms
D-c Plate Current	195	195	195	300	200	305	Milliamperes
D-c Grid Current, approx **	25	25	25	40	50	50	Milliamperes
Plate Input					600	1000	Watts
Plate Dissipation					150	225	Watts
Peak R-f Grid Voltage	640	755	870	930			Volts
Driving Power, approx **	15	17	20	34			Watts
Power Output, approx	280	370	450	780			Watts

* Averaged over any audio-frequency cycle.

† Forced ventilation from fan directed at middle and upper portions of bulb is required for continuous key-down conditions in Class C telegraph service and is recommended for other services at frequencies of 30 mc or higher.

** Subject to wide variations depending on the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits need less grid current and driving power, but plate-circuit efficiency is sacrificed. The driving stage should be capable of delivering considerably more than the required driving power.

‡ Obtained by grid resistor of value shown or by partial self-bias methods.

§ Obtained by grid resistor (16000, 20000, 24000, 12800), by cathode resistor (1800, 2300, 2700, 1730) or from fixed-bias source.

π Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

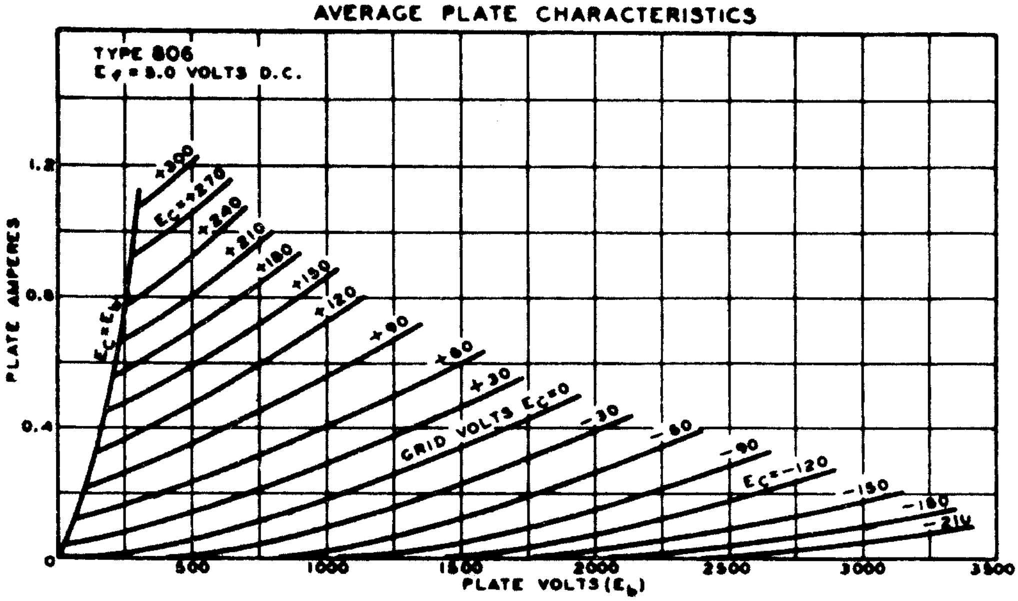
° At crest of a-f cycle with modulation factor of 1.0.

APPLICATION NOTES

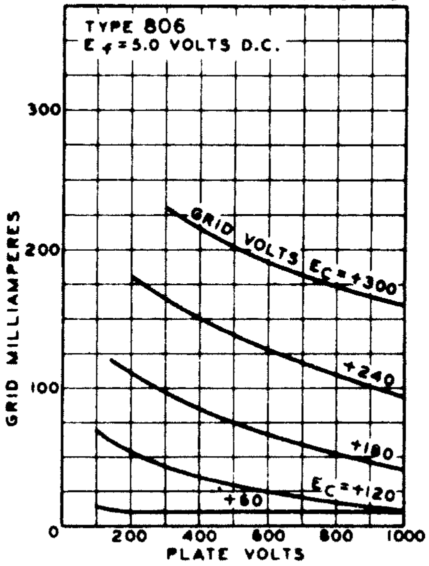
The GL-806 can be operated at frequencies as high as 30 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 100 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulbs at these frequencies.

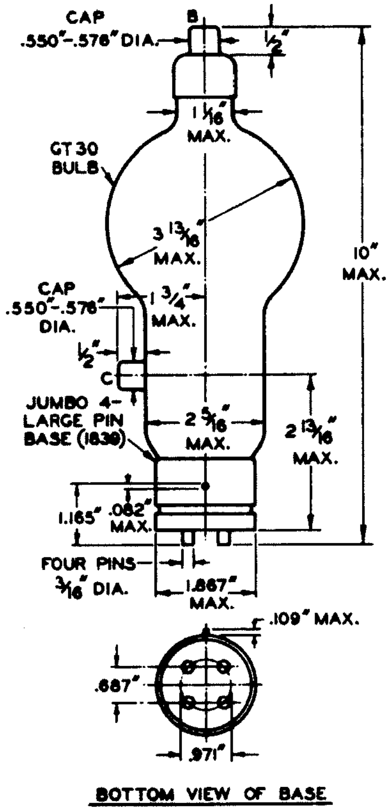
Frequency	30	50	100
Max Permissible Percentage of Max Rated Plate Voltage and Plate Input			
Class B, Class C, Grid or suppressor modulated	100	90	78
Class C, plate modulated	100	80	50
Class C, plate modulated, telegraphy	100	80	50

AVERAGE PLATE CHARACTERISTICS



TYPICAL CHARACTERISTICS

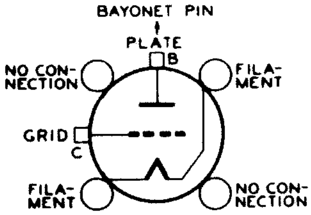




Outline Transmitting Tube GL-806

TUBE MOUNTING POSITION

Vertical: Base down
Horizontal: No.



Tube Symbol and Top View of Socket Connections

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

6-44 (8M)
Filing No. 8850

Supersedes GET-757

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-807 - - Description and Rating

Description

The 807 is a beam power transmitting tube of the heater-cathode type having a maximum plate dissipation rating of 30 watts (ICAS). The high power sensitivity of this tube makes it especially useful in frequency-multiplier service where high harmonic output is essential. The 807 may also be used as a crystal oscillator and buffer amplifier in medium-power transmitters using up to a half-kilowatt input. Neutralization is generally unnecessary in adequately shielded circuits.

Technical Information

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

ELECTRICAL

Number of Electrodes	4
Filament Voltage¶	6.3 Volts
Filament Current	0.9 Ampere
Grid-plate Transconductance, I_b = 72 ma	6000 Micromhos
Grid-screen Amplification Factor	8
Direct Interelectrode Capacitance	
Grid-plate, with external shielding	0.2 μμf
Input	11 μμf
Output	7 μμf

MECHANICAL

Base Description	Medium 5-pin
Net Weight, approx	3 Ounces
Shipping Weight, approx	3 Pounds
Installation and Operation	GEH-1112

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS AB_2ø A-F POWER AMPLIFIER (TWO TUBES)

	Typical Operation				Maximum* Ratings		
		CCS		ICAS	CCS	ICAS	
Filament Voltage				6.3			Volts
D-c Plate Voltage	400	500	600	750	600	750	Volts
Max Signal Plate Current (per tube)†					120	120	Ma
D-c Max Signal Plate Input (per tube)†					60	90	Watts
Plate Dissipation (per tube)†					25	30	Watts
D-c Grid Voltage	-25	-25	-30	-32			Volts
Positive D-c Grid Voltage	300	300	300	300	300	300	Volts
Peak A-f Grid Input Voltage (grid to grid)	78	78	78	92			Volts
Zero Signal Plate Current	100	100	60	60			Ma
Max Signal Plate Current	240	240	200	240			Ma
Max Signal Screen Grid Current	10	10	10	10			Ma
Screen Grid Input†					3.5	3.5	Watts
Peak Grid Input Power‡	0.35	0.6	0.4	0.5			Watts
Load Resistance (per tube)	800	1060	1600	1740			Ohms
Effective Load (plate to plate)	3200	4240	6400	6960			Ohms
Max Signal Plate Power Output§	55	75	80	120			Watts

	Typical Operation				Maximum* Ratings		

CLASS B R-F POWER AMPLIFIER
(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation				Maximum* Ratings		
Filament Voltage				6.3			Volts
		CCS		ICAS	CCS	ICAS	
D-c Plate Voltage	400	500	600	750	600	750	Volts
D-c Grid Voltage	-25	-25	-25	-35			Volts
D-c Screen Grid Voltage	250	250	250	300	300	300	Volts
D-c Grid Current	0	0	0	0			Ma
D-c Plate Current	75	75	62.5	60	80	90	Ma
D-c Screen Grid Current	4	4	3	3			Ma
Plate Input					37.5	45	Watts
Screen Grid Input					2.5	2.5	Watts
Plate Dissipation					25	30	Watts
Peak R-f Grid Input Voltage	30	30	20	27			Volts
Driving Power◊, approx	0.25	0.25	0.2	0.12			Watts
Plate Power Output	9	12.5	12.5	15			Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED
(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation				Maximum* Ratings		
Filament Voltage				6.3			Volts
		CCS		ICAS	CCS	ICAS	
D-c Plate Voltage	325	400	475	600	475	600	Volts
D-c Grid Voltage	-75	-80	-85	-90	-200	-200	Volts
From a grid resistor of	25000	22800	21300	22500			Ohms
D-c Screen Voltage	225	225	225	275	300	300	Volts
From a series resistor of∆	20000	30000	50000	50000			Ohms
D-c Plate Current	80	80	83	100	83	100	Ma
D-c Grid Current, approx	3	3.5	4	4	5	5	Ma
D-c Screen Grid Current	5	5.75	5	6.5			Ma
Plate Input					40	60	Watts
Screen Grid Input					2.5	2.5	Watts
Plate Dissipation					16.5	25	Watts
Peak R-f Grid Input Voltage, approx	90	95	110	115			Volts
Driving Power, approx	0.25	0.3	0.4	0.4			Watts
Plate Power Output	17.5	22.5	27.5	42.5			Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
(Key down conditions per tube without modulation)+

	Typical Operation				Maximum* Ratings		
Filament Voltage				6.3			Volts
		CCS		ICAS	CCS	ICAS	
D-c Plate Voltage	400	500	600	750	600	750	Volts
D-c Grid Voltage					-200	-200	Volts
From a fixed supply of	-45	-45	-45	-45			Volts
From a cathode resistor of	410	410	410	410			Ohms
From a grid resistor of	12800	12800	12800	12800			Ohms
D-c Screen Grid Voltage					300	300	Volts
From a fixed supply of	250	250	250	250			Volts
From a series resistor of	20000	42000	50000	85000			Ohms
D-c Plate Current	100	100	100	100	100	100	Ma
D-c Grid Current, approx	3.5	3.5	3.5	3.5	5	5	Ma
D-c Screen Grid Current	7.5	6	7	6			Ma
Plate Input					60	75	Watts
Plate Dissipation					25	30	Watts
Screen Grid Input					3.5	3.5	Watts
Peak R-f Grid Input Voltage, approx	65	65	65	65			Volts
Driving Power, approx	0.2	0.2	0.2	0.2			Watts
Plate Power Output	25	30	40	50			Watts

† Averaged over any audio-frequency cycle of sine-wave form.

+ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

∅ Subscript (2) indicates that grid current flows during some part of input cycle.

¶ Heater voltage fluctuations should not exceed +10 or -5 per cent from the rated value.

‡ Driver stage should be capable of supplying the grids of the Class AB_2 stage with the specified peak values at low distortion. The effective resistance per grid circuit of the Class AB_2 stage should be kept below 500 ohms and the effective impedance of the highest desired response frequency should not exceed 700 ohms.

§ With zero-impedance driver and perfect regulation, plate circuit distortion does not exceed 2 per cent. In practice, plate-voltage regulation, positive grid voltage regulation, and grid bias regulation should not be greater than 5 per cent, 5 per cent, and 3 per cent, respectively.

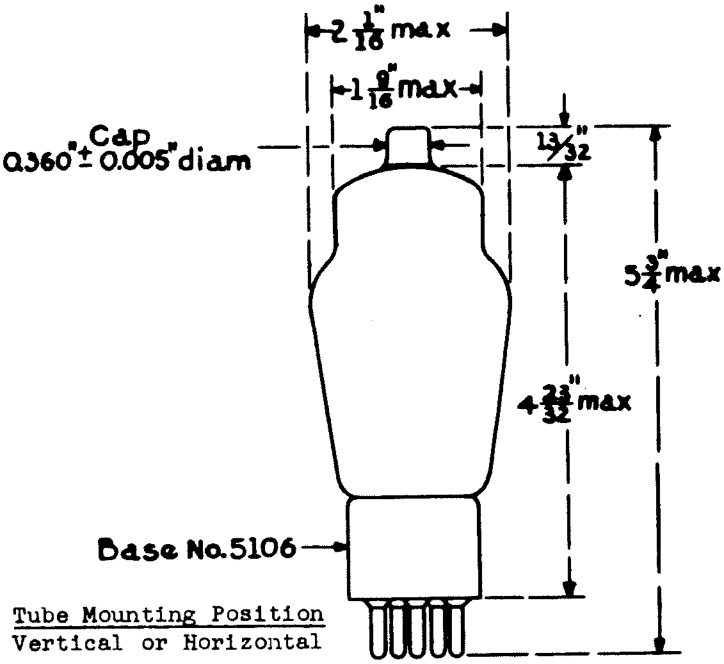
◊ At crest of a-f cycle with modulation factor of 1.0.

Δ Connected to modulated plate-voltage supply.

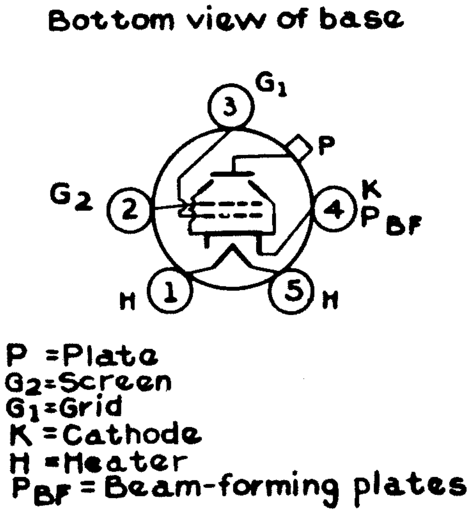
APPLICATION NOTES

* The GL-807 can be operated at frequencies as high as 60 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown above.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 125 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

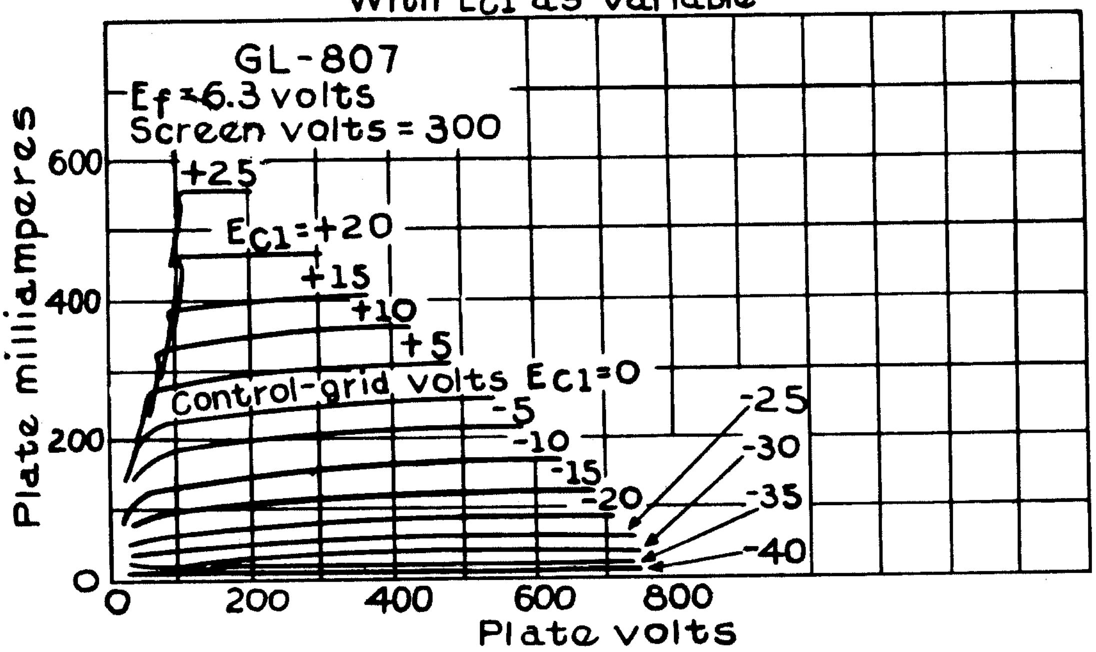
Frequency, megacycles	60	80	125
Max Permissible Percentage of Maximum Rated Plate Voltage and Plate Input			
Class B, R-F	100	90	75
plate-modulated	100	80	55
Class C, telegraphy	100	80	55



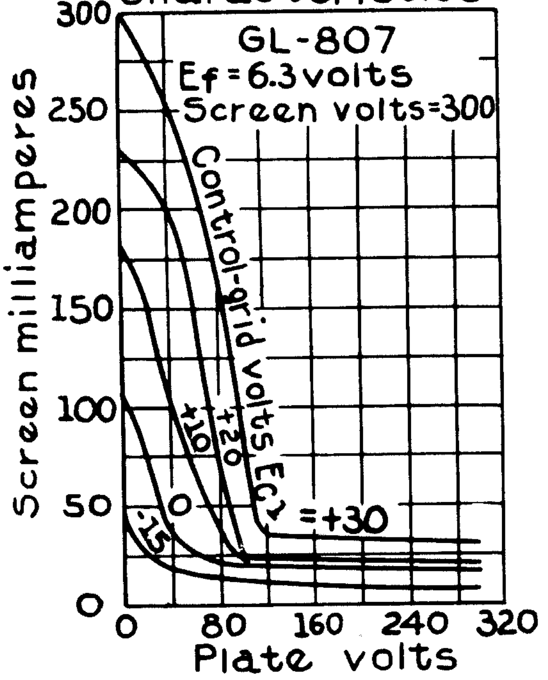
Tube Mounting Position
Vertical or Horizontal



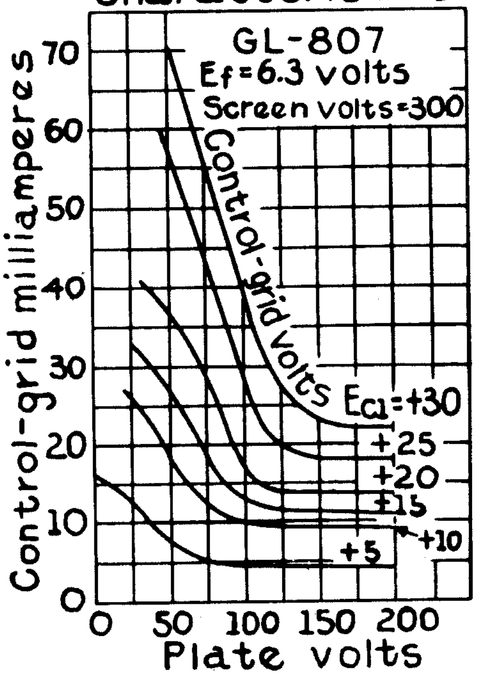
Average Plate Characteristics With E_{c1} as variable



Average Characteristics



Typical Characteristics



3-44 (7M)
Filing No. 8850
Supersedes GET-750C

GENERAL ELECTRIC

Transmitting Tube GL-809 - - Description and Rating

Description

The 809 is a high-mu transmitting triode with a typical power output of 75 watts (ICAS) for Class C telegraph service. Because of its high perveance, the tube can be operated at high plate efficiency and low driving power. Grid bias requirements are extremely low for Class B A-f service.

Technical Information

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

ELECTRICAL

Number of Electrodes	3	
Filament Voltage	6.3	Volts
Filament Current	2.5	Amperes
Amplification Factor	50	
Direct Interelectrode Capacitances		
Grid-plate	6.7	μμf
Grid-cathode	5.7	μμf
Plate-cathode	0.9	μμf

MECHANICAL

Base Description	Medium 4-pin Ceramic	
Net Weight, approx	3	Ounces
Shipping Weight, approx	3	Pounds
Installation and Operation	GEH-1114	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B A-F POWER AMPLIFIER (TWO TUBES)

	Typical Operation CCS		Typical Operation ICAS	Maximum* Ratings CCS	Maximum* Ratings ICAS	
Filament Voltage			6.3			Volts
D-c Plate Voltage	500	750	1000	750	1000	Volts
Max Signal Plate Current, per tube‡				100	100	Ma
D-c Max Signal Plate Input, per tube‡				75	100	Watts
Plate Dissipation, per tube‡				25	30	Watts
D-c Grid Voltage§	0	-4.5	-10			Volts
Peak A-f Grid Input Voltage	135	140	156			Volts
Zero Signal Plate Current	40	40	40			Ma
Max Signal Plate Current	200	200	200			Ma
Load Resistance, per tube	1300	2100	2900			Ohms
Max Signal Driving Power, approx	2.4	2.4	3.4			Watts
Effective Load, plate to plate	5200	8400	11600			Ohms
Max Signal Plate Power Output	60	100	145			Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED
(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation CCS		Typical Operation ICAS	Maximum* Ratings CCS	Maximum* Ratings ICAS	
Filament Voltage			6.3			Volts
D-c Plate Voltage	500	600	750	600	750	Volts
D-c Grid Voltage	-60	-60	-60	-200	-200	Volts
From a Grid Resistor of	2000	2000	2000			Ohms
D-c Plate Current	83	83	100	83	100	Ma
D-c Grid Current, approx◊	32	32	32	35	35	Ma

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED (CONT'D)
(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation			Maximum* Ratings		
	CCS		ICAS	CCS	ICAS	
Plate Input				50	75	Watts
Plate Dissipation				17.5	25	Watts
Peak R-f Grid Input Voltage, approx	135	135	150			Volts
Driving Power, approx◊	3.2	3.2	4.3			Watts
Plate Power Output	30	38	55			Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
(Key down conditions per tube without modulation)Δ

Filament Voltage			6.3			Volts
D-c Plate Voltage	500	750	1000	750	1000	Volts
D-c Grid Voltage	-50	-60	-75	-200	-200	Volts
From a Grid Resistor of	2500	3000	3000			Ohms
From a Cathode Resistor of	420	500	600			Ohms
D-c Plate Current	100	100	100	100	100	Ma
D-c Grid Current, approx◊	20	20	25	35	35	Ma
Plate Input				75	100	Watts
Plate Dissipation				25	30	Watts
Peak R-f Grid Input Voltage, approx	135	140	160			Volts
Driving Power, approx◊	2.5	2.5	3.8			Watts
Plate Power Output	35	55	75			Watts

‡ Averaged over any audio-frequency cycle of sine-wave form.

§ Grid voltages are given with respect to the midpoint of filament operated on alternating current. If direct current is used, each stated value of grid voltage should be reduced by one-half the filament voltage and the circuit returns made to the negative end of the filament.

◊ Subject to wide variations depending upon the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits need less grid current and driving power, but plate circuit efficiency is sacrificed. The driving stage should be capable of delivering considerably more than the required driving power.

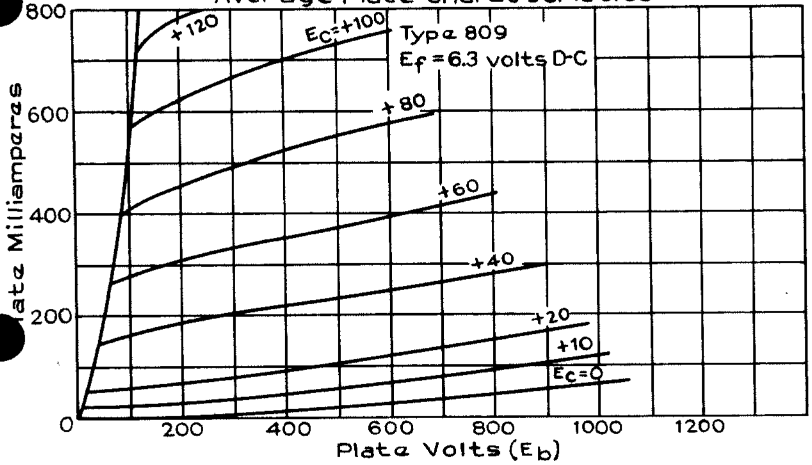
Δ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

APPLICATION NOTES

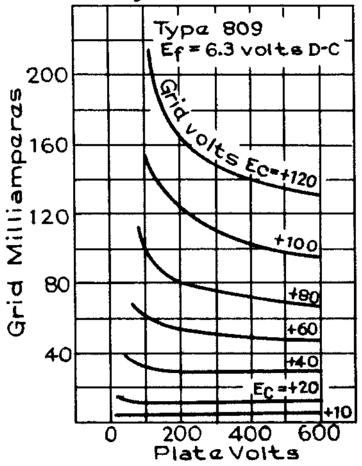
* The GL-809 can be operated at frequencies as high as 60 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 120 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

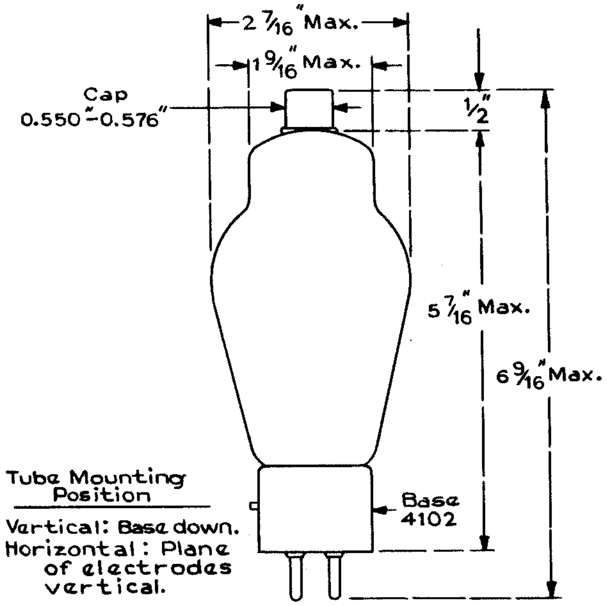
Frequency, megacycles	60	70	120
Max Permissible Percentage of Max Rated Plate Voltage and Plate Input			
Class B, R-f	100	93	75
Class C, plate-modulated	100	88	50
telegraphy	100	88	50

Average Plate Characteristics

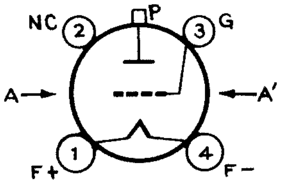


Average Characteristics





Bottom View of Sockect Connections



AA' = Plane of electrodes

P = Plate
G = Grid
F = Filament
NC = No connection

GENERAL ELECTRIC

SCHENECTADY, N.Y.

Supersedes GET-758A

4-44 (8M)
Filing No. 8850

PRINTED IN U.S.A.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-810--Description and Rating

The GL-810 is a high-mu transmitting tube with a typical power output of 475 watts (ICAS) for Class C telegraph service. Because of its high perveance the tube can be operated at high plate efficiency with low driving power and relatively low plate voltage. The 810 heavy duty filament, shielded at each end, conserves input power by eliminating bulb bombardment and stray electrons. The plate and grid leads are brought out to terminals at the top and side of the bulb respectively - a design which provides very short internal leads, low internal lead inductance, and permits compact circuit layout for h-f installations.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

ELECTRICAL	
Number of Electrodes	3
Filament Voltage	10 volts
Filament Current	4.5 amperes
Amplification Factor	36
Direct Interelectrode Capacitance, μμf	
Grid-plate	4.8
Grid-cathode	8.7
Plate-cathode	12
MECHANICAL	
Base Description	Jumbo 4-large Pin
Net Weight, approx	8 ounces
Shipping Weight, approx	1 pound
Installation and Operation	GEH-1111

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

	Typical Operation			Maximum* Ratings		
CLASS B A-F POWER AMPLIFIER (TWO TUBES)						
Filament Voltage				10		volts
	CCS		IC & AS	CCS	IC & AS	
D-c Plate Voltage	1500	2000	2250	2000	2250	volts
Max Signal Plate Current (per tube)†				250	250	milliamperes
D-c Max Signal Plate Input (per tube)†				425	510	watts
Plate Dissipation (per tube)†				125	150	watts
D-c Grid Voltage	-30	-50	-60			volts
Peak A-f Grid Input Voltage	345	345	380			volts
Zero Signal Plate Current	80	60	70			milliamperes
Max Signal Plate Current	500	420	450			milliamperes
Max Signal Driving Power, approx	12	10	13			watts
Effective Load (plate to plate)	6600	11000	11600			ohms
Max Signal Plate Power Output	510	590	725			watts

	Typical Operation			Maximum* Ratings		
CLASS B R-F POWER AMPLIFIER						
(Carrier conditions per tube for use with a max modulation factor of 1.0)						
Filament Voltage				10		volts
	CCS		IC & AS	CCS	IC & AS	
D-c Plate Voltage	1500	2000	2250	2000	2250	volts
D-c Grid Voltage	-50	-65	-70			volts
D-c Plate Current	115	93	100	185	185	milliamperes
Plate Input				185	225	watts
D-c Grid Current	2	2	2			milliamperes
Plate Dissipation				125	150	watts
Peak R-f Grid Input Voltage	110	100	100			volts
Driving Power ‡, approx	6	4	4			watts
Plate Power Output	60	60	75			watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - GRID MODULATED						
(Carrier conditions per tube for use with a max modulation factor of 1.0)						
Filament Voltage				10		volts
D-c Plate Voltage	1500	2000	2250	2000	2250	volts
D-c Grid Voltage	-140	-140	-140	-500	-500	volts
D-c Plate Current	110	92	100	185	185	milliamperes
D-c Grid Current, approx	2	2	2			milliamperes
Plate Input				185	225	watts
Plate Dissipation				125	150	watts
Peak R-f Grid Input Voltage, approx	175	160	180			volts
Driving Power ‡, approx	5	4	4			watts
Plate Power Output	60	60	75			watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED						
(Carrier conditions per tube for use with a max modulation factor of 1.0)						
Filament Voltage				10		volts
D-c Plate Voltage	1250	1600	1800	1600	1800	volts
D-c Grid Voltage ¶	-200	-200	-200	-500	-500	volts
	4000	4000	4000			ohms
D-c Plate Current	210	210	250	210	250	milliamperes
D-c Grid Current, approx	50	50	50	70	70	milliamperes
Plate Input				335	450	watts
Plate Dissipation				85	125	watts
Peak R-f Grid Input Voltage, approx	370	370	370			volts
Driving Power, approx	17	17	17			watts
Plate Power Output	180	250	335			watts

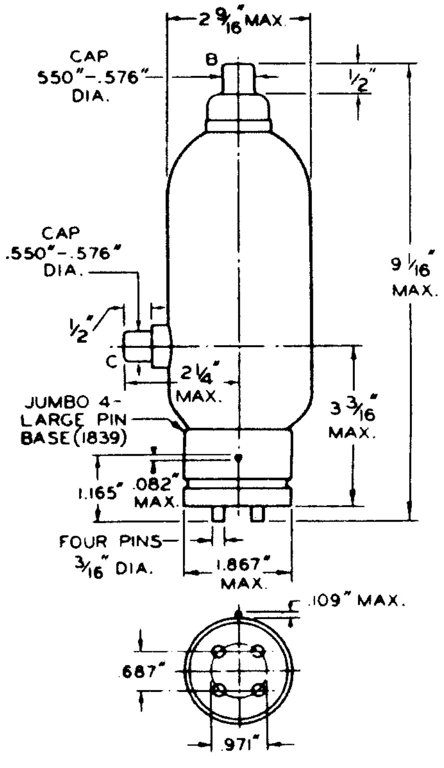
CLASS C R-F POWER AMPLIFIER AND OSCILLATOR						
(Key down conditions per tube without modulation)§						
Filament Voltage				10		volts
D-c Plate Voltage	1500	2000	2250	2000	2250	volts
D-c Grid Voltage π	-120	-160	-160	-500	-500	volts
	3000	4000	4000			ohms
	415	550	510			ohms
D-c Plate Current	250	250	275	250	275	milliamperes
D-c Grid Current	40	40	40	70	70	milliamperes
Plate Input				500	620	watts
Plate Dissipation				125	150	watts
Peak R-f Grid Input Voltage, approx	280	330	330			volts
Driving Power, approx	10	12	12			watts
Plate Power Output	275	375	475			watts

† Averaged over any audio-frequency cycle
‡ At crest of audio-frequency cycle
¶ Obtained by grid-resistor of value shown or by partial self-bias methods
§ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions
π Obtained from fixed supply, by grid resistor (3000, 4000), or by cathode resistor (415, 550, 510)

APPLICATION NOTES

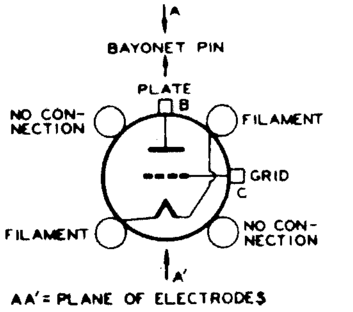
* The GL-810 can be operated at frequencies as high as 30 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 100 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

Frequency, megacycles	30	60	100
Max Permissible Percentage of Max Rated Plate Voltage and Plate Input			
Class B	100	88	80
Class C, Grid-modulated	100	88	80
Plate-modulated	100	70	50
Telegraphy	100	70	50



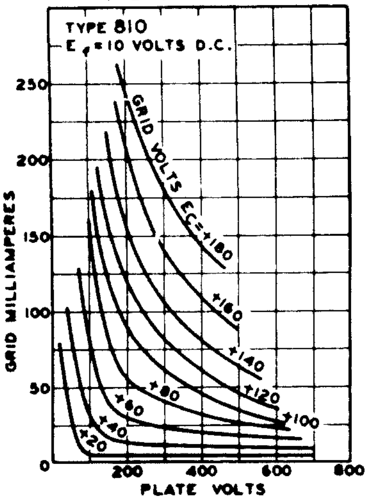
BOTTOM VIEW OF BASE

Top View of Socket Connections

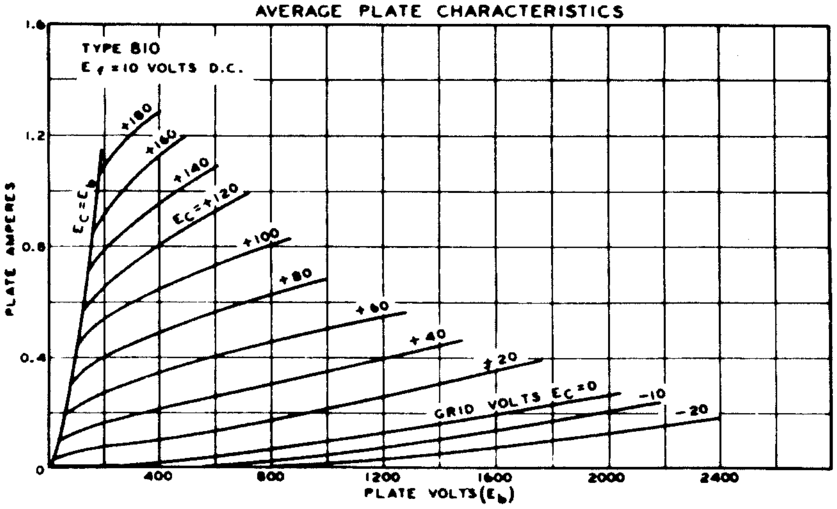


Tube Mounting Position
Vertical - Base Down
Horizontal - Plane of Electrodes Vertical

TYPICAL CHARACTERISTICS



AVERAGE PLATE CHARACTERISTICS



G E N E R A L E L E C T R I C C O M P A N Y , S C H E N E C T A D Y , N . Y .

7-44 (8M)
Filing No. 8850

Supersedes GET-755

GENERAL ELECTRIC

Transmitting Tube GL-811 - - Description and Rating

The 811 is a high mμ transmitting triode designed for Class B modulator service. In this service, two tubes are capable of modulating 100 per cent an r-f amplifier operating with 450 watts input; no grid bias is required at plate voltages up to 1250 volts. The 811 is also an excellent radio-frequency amplifier and frequency doubler. The tube may be operated at maximum ratings in r-f services at frequencies as high as 60 mc and at reduced ratings as high as 100 mc. Because of its high perveance, it can be operated at high plate efficiency and low driving power. For example, two tubes in Class B a-f service may be used with a plate input of 300 watts (ICAS) and with only 4.2 watts of driving power.

Technical Information

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

ELECTRICAL	
Number of Electrodes	3
Filament Voltage	6.3 volts
Filament Current	4 amperes
Amplification Factor	160
Direct Interelectrode Capacitance, μμf	
Grid-plate	5.5
Grid-cathode	5.5
Plate-cathode	0.6
MECHANICAL	
Base Description	Medium 4-pin Micanol‡, Bayonet
Net Weight, approx	4 ounces
Shipping Weight, approx	3 pounds
Installation and Operation	GEH-1110

‡ Registered Trademark.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

	Typical Operation CCS	Typical Operation IC & AS	Maximum* Ratings CCS	Maximum* Ratings IC & AS	
CLASS B A-F POWER AMPLIFIER (TWO TUBES)					
Filament Voltage		6.3			volts
D-c Plate Voltage	1250	1500	1250	1500	volts
Max Signal Plate Current (per tube)†			125	125	milliamperes
D-c Max Signal Plate Input (per tube)†			125	150	watts
Plate Dissipation (per tube)†			40	50	watts
D-c Grid Voltage#	0	0			volts
Peak A-f Grid Input Voltage	140	160			volts
Zero Signal Plate Current	48	20			milliamperes
Max Signal Plate Current	200	200			milliamperes
Load Resistance (per tube)	3750	4500			ohms
Max Signal Driving Power, approx	3.8	4.2			watts
Effective Load (plate to plate)	15000	18000			ohms
Max Signal Plate Power Output	175	225			watts
CLASS B R-F POWER AMPLIFIER					
(Carrier conditions per tube for use with a max modulation factor of 1.0)					
Filament Voltage		6.3			volts
D-c Plate Voltage	1250	1500	1250	1500	volts

	Typical Operation		Maximum Ratings		
	CCS	IC & AS	CCS	IC & AS	
D-c Grid Voltage#	0	-6			volts
D-c Plate Current	48	50	60	60	milliamperes
Plate Input			60	75	watts
D-c Grid Current**	6	6			milliamperes
Plate Dissipation			40	50	watts
Peak R-f Grid Input Voltage	26	35			volts
Driving Power, approx**π	1	1.5			watts
Plate Power Output	20	25			watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED
(Carrier conditions per tube for use with a max modulation factor of 1.0)

Filament Voltage			6.3		volts
D-c Plate Voltage	1000	1250	1000	1250	volts
D-c Grid VoltageΔ	-100	-125	-200	-200	volts
From a Grid Resistor of	2000	2500			ohms
D-c Plate Current	105	125	105	125	milliamperes
D-c Grid Current, approx**	50	50	50	50	milliamperes
Plate Input			105	155	watts
Plate Dissipation			27	40	watts
Peak R-f Grid Input Voltage, approx	195	230			volts
Driving Power, approx**	9	11			watts
Plate Power Output	82	120			watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
(Key down conditions per tube without modulation)§

Filament Voltage			6.3		volts
D-c Plate Voltage	1250	1500	1250	1500	volts
D-c Grid Voltage◊			-200	-200	volts
From a Fixed Supply of	-87.5	-113			volts
From a Grid Resistor of	2500	3200			ohms
From a Cathode Resistor of	550	610			ohms
D-c Plate Current	125	150	125	150	milliamperes
D-c Grid Current**	35	35	50	50	milliamperes
Plate Input			155	225	watts
Plate Dissipation			40	55	watts
Peak R-f Grid Input Voltage, approx	180	225			volts
Driving Power, approx**	7	8			watts
Plate Power Output	115	170			watts

† Averaged over any audio-frequency cycle.

\# Grid voltages are given for either a-c or d-c filament operation. When a.c is used the circuit returns are made to the midpoint of the filament circuit. When d.c. is used, the returns are made to the negative filament terminal.

** Subject to wide variations depending on the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low impedance circuits need less grid current and driving power, but plate-circuit efficiency is sacrificed. The driving stage should be capable of delivering considerably more than the required driving power.

§ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

Δ Obtained preferably from grid leak of value shown, or combination of grid leak with either fixed supply or suitably by-passed cathode resistor.

◊ Obtained from fixed supply or grid resistor (2500, 3200) or by cathode resistor (550, 610).

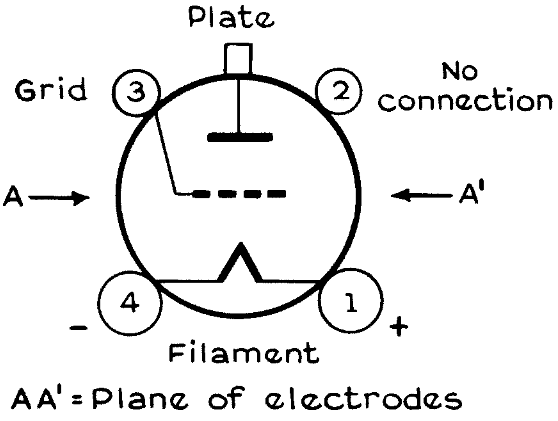
π At crest of audio-frequency cycle with modulation factor of 1.0.

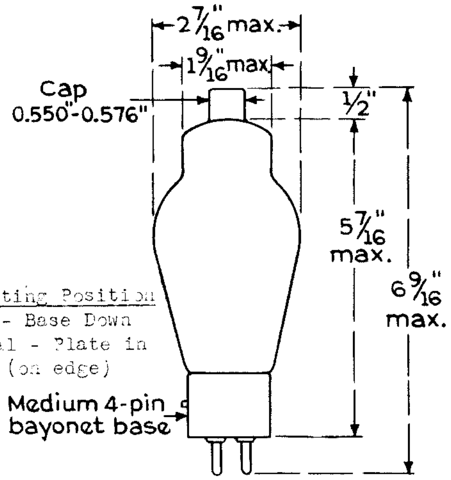
APPLICATION NOTES

* The GL-811 can be operated at frequencies as high as 60 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 100 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

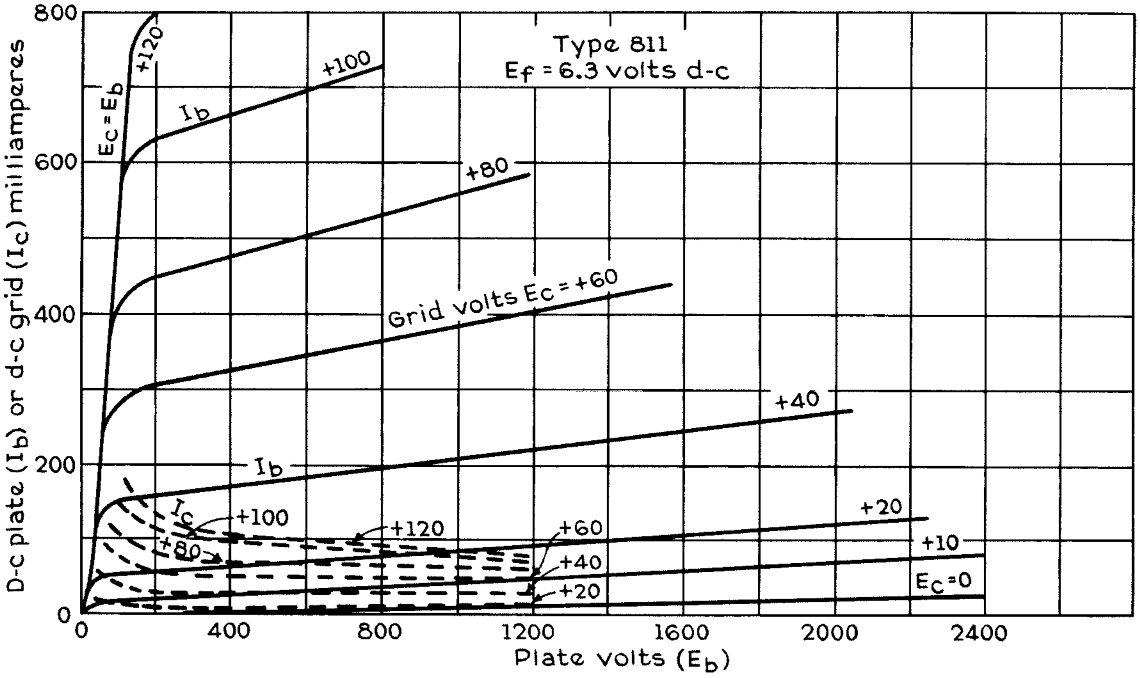
Frequency, megacycles	60	80	100
Max Permissible Percentage of Max Rated Plate Voltage and Plate Input			
Class B	100	90	83
Class C			
Plate-modulated	100	75	60
Telegraphy	100	75	60

Top View of Socket Connections





Tube Mounting Position
Vertical - Base Down
Horizontal - Plate in Plane (on edge)



GENERAL ELECTRIC
SCHENECTADY, N.Y.

1-42 (4M)
Filing No. 8850

Supersedes GET-754

PRINTED IN U.S.A.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-812 - - Description and Rating

The 812 is a transmitting triode with a maximum plate dissipation of 55 watts for Class C telegraph service. Because of its high perveance, the tube can be operated at high plate efficiency and low driving power. In Class B modulator service, two 812's are capable of modulating 100 per cent an r-f amplifier having an input of 450 watts.

Other features of the 812 include its use of a Zirconium-coated plate which has remarkably high heat-dissipating qualities and which functions as an exceptionally effective getter. The 812 is equipped with the new low-loss Micanol† base which has excellent insulating qualities at high radio frequencies together with low moisture-absorption characteristics. The plate connection of the tube is brought out through a separate seal at the top of the bulb to maintain high insulation.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Electrical

Number of Electrodes	3
Filament Voltage	6.3 Volts
Filament Current	4 Amperes
Amplification Factor	29
Direct Interelectrode Capacitances	
Grid-plate	5.3 uuf
Grid-cathode	5.3 uuf
Plate-cathode	0.8 uuf

Mechanical

Base Description	Medium 4-pin Micanol†
Net Weight, approx	3 Ounces
Shipping Weight, approx	1 Pound
Installation and Operation	GEH-1108

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

	Typical Operation		Maximum* Ratings		
CLASS B A-F POWER AMPLIFIER (TWO TUBES)					
Filament Voltage		6.3			Volts
	CCS	IC-AS	CCS	IC-AS	
D-c Plate Voltage	1250	1500	1250	1500	Volts
Max Signal Plate Current, per tube‡			125	125	Amperes
D-c Max Signal Plate Input, per tube‡			125	150	Watts
Plate Dissipation, per tube‡			40	50	Watts
D-c Grid Voltage§	-36	-46			Volts
Peak A-f Grid Input Voltage	210	232			Volts

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS (CONT'D)

	Typical Operation		Maximum* Ratings		
	CCS	IC-AS	CCS	IC-AS	
Zero Signal Plate Current	48	42			Ma
Max Signal Plate Current	200	200			Ma
Load Resistance, per tube	3750	4500			Ohms
Max Signal Driving Power, approx	4.3	4.7			Watts
Effective Load, plate to plate	15000	18000			Ohms
Max Signal Plate Power Output	175	225			Watts

CLASS B R-F POWER AMPLIFIER

Carrier conditions per tube for use with a max modulation factor of 1.0

Filament Voltage		6.3			Volts
D-c Plate Voltage	1250	1500	1250	1500	Volts
D-c Grid Voltage§	-35	-45			Volts
D-c Grid Current, approx◊	1.0	1.1			Ma
D-c Plate Current	48	50	60	60	Ma
Plate Input			60	75	Watts
Plate Dissipation			40	50	Watts
Peak R-f Grid Input Voltage	46	51			Volts
Driving Power, approx¶◊	1.2	1.5			Watts
Plate Power Output	20	25			Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED

Carrier conditions per tube for use with a max modulation factor of 1.0

Filament Voltage		6.3			Volts
D-c Plate Voltage	1000	1250	1000	1250	Volts
D-c Grid Voltage	-100	-125	-200	-200	Volts
From a Grid Resistor of	4000	5000			Ohms
D-c Plate Current	105	125	105	125	Ma
D-c Grid Current, approx◊	25	25	25	25	Ma
Plate Input			105	155	Watts
Plate Dissipation			27	40	Watts
Peak R-f Grid Input Voltage, approx	180	245			Volts
Driving Power, approx◊	4.5	6			Watts
Plate Power Output	82	120			Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR

Key down conditions per tube without modulation∆

Filament Voltage		6.3			Volts
D-c Plate Voltage	1250	1500	1250	1500	Volts
D-c Grid Voltage			-200	-200	Volts
From a fixed supply of	-125	-175			Volts
From a Grid Resistor of	5000	7000			Ohms
From a Cathode Resistor of	835	1000			Ohms
D-c Plate Current	125	150	125	150	Ma
D-c Grid Current, approx◊	25	25	35	35	Ma
Plate Input			155	225	Watts
Plate Dissipation			40	55	Watts
Peak R-f Grid Input Voltage, approx	215	285			Volts
Driving Power, approx◊	5	6.5			Watts
Plate Power Output	116	170			Watts

AS SELF-RECTIFYING OSCILLATOR

	CCS (Two Tubes)	CCS (Per Tube)	
A-c Plate Voltage, rms	1500	1500	Volts

AS SELF-RECTIFYING OSCILLATOR

	CCS (Two Tubes)	CCS (Per Tube)	
D-c Grid Voltage		-125	Volts
D-c Plate Current	150	75	Ma
D-c Grid Current	25	20	Ma
Plate Input		125	Watts
Plate Dissipation		40	Watts
Grid Resistor	5000		Ohms
Peak R-f Grid Voltage		350	Volts
Plate Power Output	170		Watts
Useful Power Output, circuit efficiency 80 per cent	140		Watts

† Registered trade-mark

‡ Averaged over any audio-frequency cycle of sine-wave form

§ Grid voltages are given with respect to the midpoint of filament operated on alternating current. If direct current is used, each stated value of grid voltage should be reduced by one-half the filament voltage and the circuit returns made to the negative end of the filament.

◊ Subject to wide variations depending upon the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits need less grid current and driving power, but plate circuit efficiency is sacrificed. The driving stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.

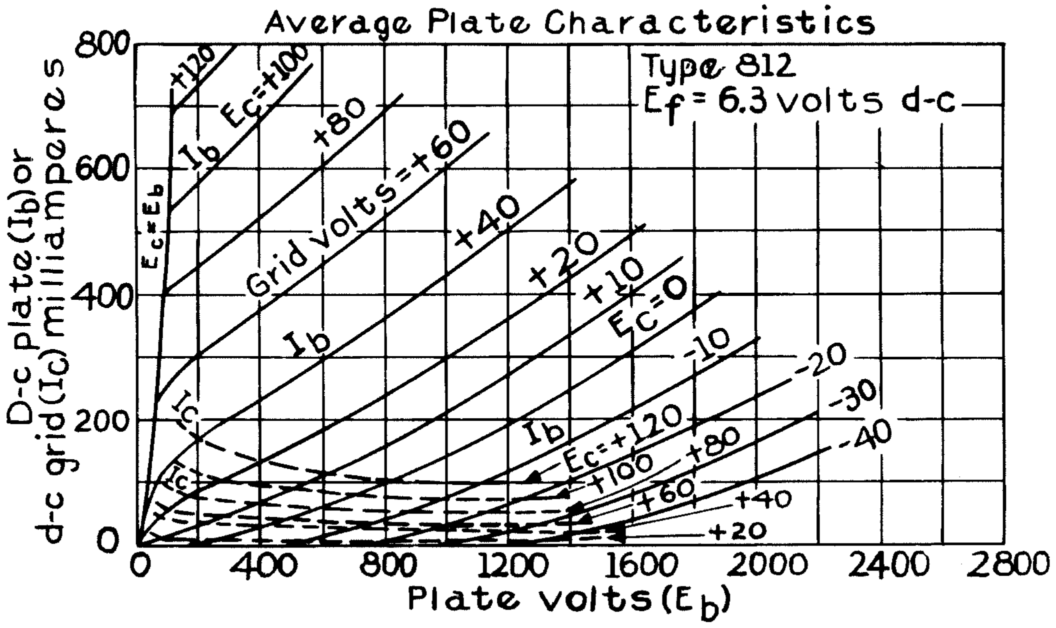
¶ At crest of audio cycle with modulation factor of 1.0

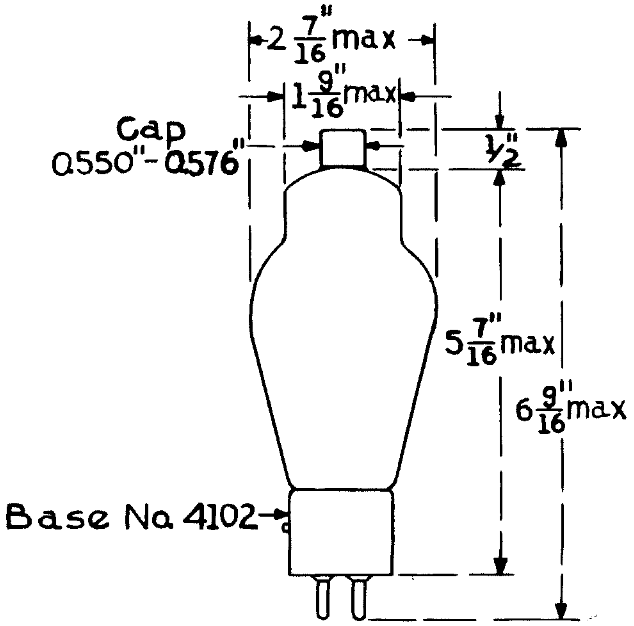
Δ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

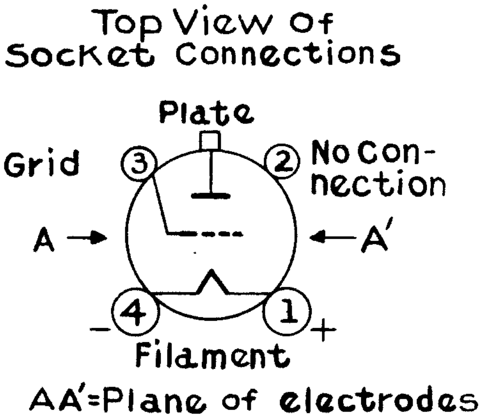
APPLICATION NOTES

* The GL-812 can be operated at frequencies as high as 60 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 100 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

Frequency, megacycles	60	80	100
Max Permissible Percentage of Max Rated Plate Voltage and Plate Input			
Class B, R-f	100	90	83
Class C, plate-modulated	100	75	60
Class C, telegraphy	100	75	60







Mounting Position
Vertical: Base down
Horizontal: Plane of electrodes vertical

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-813--- Description and Rating

The 813 is a beam power transmitting tube of extremely high-power sensitivity with a typical power output of 260 watts for Class C telegraph service. Full power output can be obtained with very little driving power and with a reduced number of driver stages. Neutralization is unnecessary in adequately shielded circuits. The 813 makes an excellent power amplifier for the final stage of high-power amateur transmitters where quick band change without neutralizing adjustments is desirable. It is also an excellent high-power frequency multiplier and is capable of giving high harmonic output with unusually high efficiency. The reduced over-all length of the tube provides for short internal leads and minimizes lead inductance.

Technical Information

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

ELECTRICAL

Cathode - Filamentary	
Number of Electrodes	4
Filament Voltage, a-c or d-c	10.0 Volts
Filament Current	5 Amperes
Grid-plate Transconductance, I_b = 50 ma	3750 Micromhos
Direct Interelectrode Capacitances	
Grid-plate, with external shielding	0.2 uuf
Input	16.3 uuf
Output	14 uuf

MECHANICAL

Base Description	Giant 7-pin, Bayonet
Net Weight, approx	4 Ounces
Shipping Weight, approx	3 Pounds
Installation and Operation	GEH-1103

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B R-F POWER AMPLIFIER
(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation		Maximum Ratings	
Filament Voltage	10.0			Volts
D-c Plate Voltage	1500	2000	2000	Volts
D-c Grid Voltage*	-60	-75		Volts
D-c Screen Grid Voltage	400	400	400	Volts
D-c Grid Current†	0	0		Ma
D-c Plate Current	100	75	100	Ma
D-c Screen Grid Current	4	3		Ma
Plate Input			150	Watts
Screen Grid Input			15	Watts
Plate Dissipation			100	Watts
Peak R-f Grid Input Voltage	70	80		Volts
D-c Suppressor Voltage	0	0		
Driving Power‡, approx	0	0		Watts
Plate Power Output	50	50		Watts

CLASS C GRID-MODULATED R-F POWER AMPLIFIER
(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation		Maximum Ratings	
Filament Voltage	10.0			Volts
D-c Plate Voltage	1500	2000	2000	Volts

CLASS C GRID-MODULATED R-F POWER AMPLIFIER (Cont'd)
(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation		Maximum Ratings	
D-c Grid Voltage	-140*	-120*	-200	Volts
D-c Screen Voltage	400	400	400	Volts
D-c Plate Current	70	75	100	Ma
D-c Grid Current, approx	-	-		
D-c Screen Grid Current	3	3		Ma
Plate Input			150	Watts
Screen Grid Input			15	Watts
Plate Dissipation			100	Watts
Peak R-f Grid Input Voltage, approx	145	120		Volts
Peak A-f Grid Voltage	60	60		Volts
D-c Suppressor Voltage	0	0		Volts
Driving Power‡, approx	-	-		
Plate Power Output	40	50		Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED
(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation		Maximum Ratings	
Filament Voltage		10.0		Volts
D-c Plate Voltage	1250	1600	1600	Volts
D-c Grid Voltage, from a fixed supply of	-120*	-130*	-300	Volts
From a grid resistor of §	30000	21600		Ohms
D-c Screen Voltage	400	400	400	Volts
D-c Plate Current	150	150	150	Ma
D-c Grid Current, approx	4	6	25	Ma
D-c Screen Grid Current	16	20		Ma
Plate Input			240	Watts
Screen Grid Input			15	Watts
Plate Dissipation			67	Watts
Peak R-f Grid Input Voltage, approx	195	210		Volts
D-c Suppressor Voltage	0	0		
Driving Power, approx	0.7	1.2		Watts
Plate Power Output	135	175		Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
(Key down conditions per tube without modulation)**

	Typical Operation			Maximum Ratings	
Filament Voltage			10.0		Volts
D-c Plate Voltage	1250	1500	2000	2000	Volts
D-c Grid Voltage¶				-300	Volts
From a fixed supply of	-60	-70	-90		Volts
From a cathode resistor of	285	340	455		Ohms
From a grid resistor of	8500	11700	30000		Ohms
D-c Screen Grid Voltageπ				400	Volts
From a fixed supply of	300	300	400		Volts
From a series resistor of	42000	60000	107000		Ohms
D-c Plate Current	180	180	180	180	Ma
D-c Grid Current, approx	7	6	3	25	Ma
D-c Screen Grid Current	23	20	15		Ma
Plate Input				360	Watts
Plate Dissipation				100	Watts
Screen Grid Input				22	Watts
Peak R-f Grid Input Voltage, approx	145	150	160		Volts
D-c Suppressor Voltage	0	0	0		
Driving Power, approx	1	0.8	0.5		Watt
Plate Power Output	155	190	260		Watts

APPLICATION NOTES

The GL-813 can be operated at frequencies as high as 30 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown above.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 60 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

Frequency, Megacycles	30	45	60
Max Permissible Percentage of Max Rated Plate Voltage and Plate Input			
Class B, r-f	100	93	88
Class C, grid-modulated	100	93	88
plate-modulated	100	87	75
Class C, telegraphy	100	87	75

(Notes for Pages 1 and 2)

* For a-c filament supply. If d-c is used, the stated voltages should be decreased by one-half the filament voltage.

† Usually negligible. Fixed supply or by-passed cathode-resistor bias recommended.

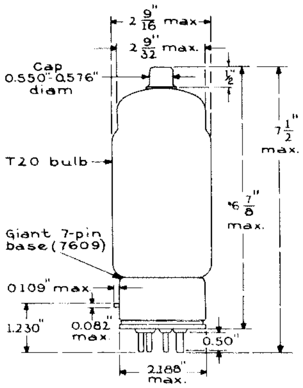
‡ At crest of audio-frequency cycle with modulation factor of 1.0.

§ Total effective grid-circuit resistance should not exceed 30,000 ohms.

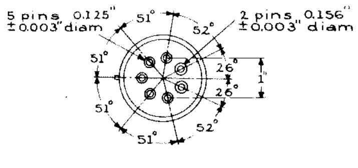
** Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

¶ Obtained from fixed supply, by grid resistor (8500, 11,700, 30,000) or cathode resistor (285, 340, 455). If preceding stage is keyed, partial fixed bias is required.

π Obtained from a separate source, or from the plate-voltage supply with a voltage divider, or through a series resistor of the value shown. Series screen resistor should be used only where the 813 is employed as buffer amplifier and is not keyed. The screen voltage must not exceed 800 volts under key-up conditions.

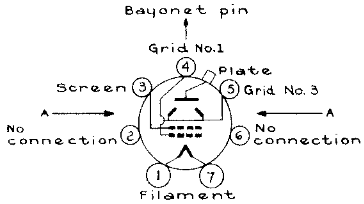


Tube Mounting Position
Vertical - Base up or down
Horizontal - Plate in Vertical Plane (on edge)

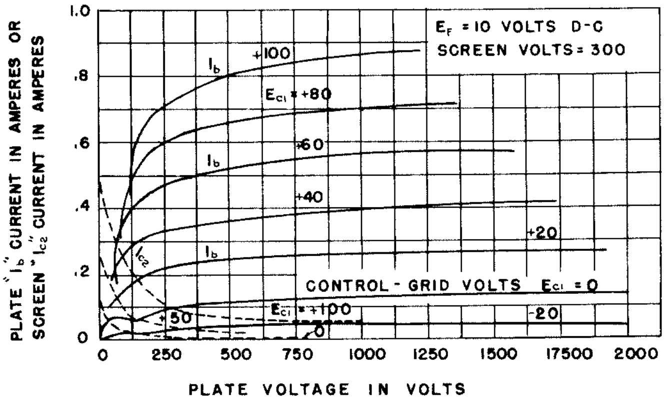


Bottom view of base

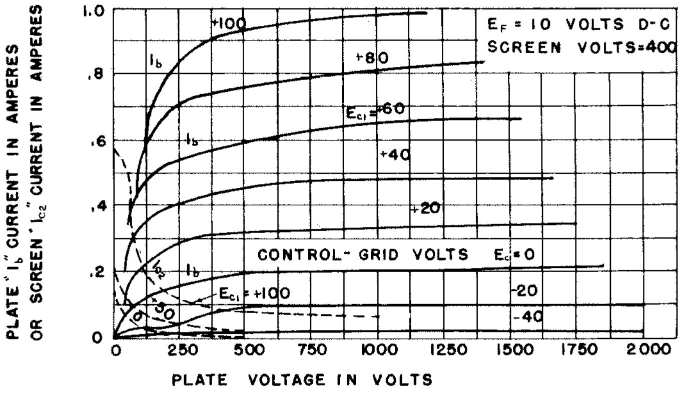
Bottom view of socket connections



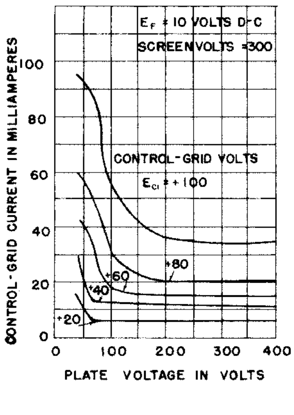
AA = Plane of electrodes



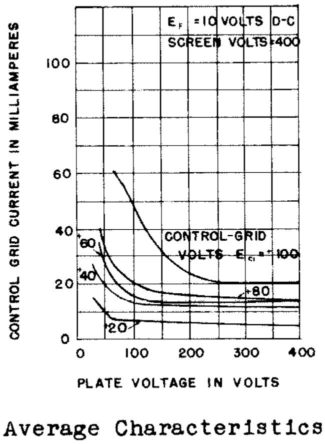
Average Plate Characteristics
K-8639610 February 5, 1944



Average Plate Characteristics
K-8639611 December 23, 1943



Average Characteristics
K-8639612 February 5, 1944



Average Characteristics
K-8639613 February 5, 1944

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

2-44 (6M)
Filing No. 8850

Supersedes GET-747A
Printed in U. S. A.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-814--Description and Rating

GL-814 is a filament type of transmitting tube incorporating new design principles involving the use of directed electron beams. Features resulting from the use of these principles in the 814 are that the screen absorbs little power and that efficient suppressor action is supplied by space-charge effects produced between the screen and the plate. The resultant high power sensitivity makes this tube especially suited for use as an r-f amplifier, frequency multiplier, oscillator, and plate-modulated amplifier. The plate connection is brought out through a separate seal at the top of the bulb to maintain low grid-plate capacitance.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL DESIGN

Electrical

Filament		Filamentary
Voltage	10	Volts
Current	3.25	Amperes
Grid-plate Transconductance	3300	Micromhos
Direct Interelectrode Capacitances		
Grid-plate	0.15	
Input or grid - filament	13.5	
Output or plate - filament	13.5	
Frequency for Maximum Ratings	30	Megacycles

Mechanical

Type of Cooling		Convection (Maximum Ambient 60 C)
Cap Description		No. 3907
Base Description		Medium 5-pin, ceramic, No. 5106
Mounting Position	Vertical:	Base Down
	Horizontal:	Filament in vertical plane (on edge)

Maximum Over-all Dimensions (See Outline)		
Length	7 5/8	Inches
Diameter	2 1/16	Inches
Net Weight, approximate	8	Ounces
Shipping Weight, approximate	8	Pounds
Installation and Operation Instruction	GEH-1127	

CLASS B RADIO-FREQUENCY POWER AMPLIFIER
(Carrier Conditions per Tube for Use with a Maximum Modulation Factor of 1.0)

	Typical Operation			Maximum Ratings		
	CCS		IC and AS	CCS	IC and AS	
D-c Plate Voltage	1000	1250	1500	1250	1500	Volts
D-c Grid Voltage (Grid No. 1)	-28	-28	-35			Volts
D-c Grid Voltage (Grid No. 2) etc.	200	200	250	400	400	Volts

CLASS B RADIO-FREQUENCY POWER AMPLIFIER (CONT'D)

	Typical Operation			Maximum Ratings		
	CCS		IC and AS	CCS	IC and AS	
D-c Plate Current	60	60	60	60	60	Milliamperes
Plate Input				75	90	Watts
Screen Input				6.7	6.7	Watts
Plate Dissipation				50	60	Watts
Peak R-F Grid Input Voltage	50	50	56			Volts
Driving Power*, approximate	0.65	0.65	0.85			Watts
Plate Power Output, approximate	20	25	30			Watts

*At the crest of audio-frequency cycle.

CLASS C RADIO-FREQUENCY POWER AMPLIFIER GRID MODULATED
(Carrier Conditions per Tube for Use with a Maximum Modulation Factor of 1.0)

	Typical Operation			Maximum Ratings		
	CCS		IC and AS	CCS	IC and AS	
D-c Plate Voltage	1000	1250	1500	1250	1500	Volts
D-c Grid Voltage (Grid No. 1)	-100	-100	-120	-250	-250	Volts
D-c Grid Voltage (Grid No. 2) etc.	200	200	250	400	400	Volts
Beam Forming Plate Voltage	0	0	0			Volts
D-c Plate Current	60	60	60	60	60	Milliamperes
D-c Grid Current, approximate	3	2.8	2.5			Milliamperes
D-c Screen Current	2	1.4	3			Watts
Plate Input				75	90	Watts
Screen Input				6.7	6.7	Watts
Plate Dissipation				50	60	Watts
Peak R-F Grid Input Voltage	129	129	150			Volts
Peak A-F Grid Voltage	64	64	90			Volts
Driving Power, approximate	2.5	2.3	4.2			Watts
Plate Power Output	25	29	35			Watts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR, PLATE MODULATED
(Carrier Conditions per Tube for Use with a Maximum Modulation Factor of 1.0)

	Typical Operation			Maximum Ratings		
	CCS		IC and AS	CCS	IC and AS	
D-c Plate Voltage	900	1000	1250	1000	1250	Volts
D-c Grid Voltage (Grid No. 1)	-150	-150	-150	-300	-300	Volts
D-c Grid Voltage (Grid No. 2)	300	300	300	400	400	Volts
D-c Plate Current	120	120	144	120	150	Milliamperes
D-c Grid Current, approx	10	10	10	15	15	Milliamperes
Plate Input				120	180	Watts
Screen Input				6.7	6.7	Watts
Plate Dissipation				34	50	Watts
Peak R-F Grid Input Voltage	215	222	222			Volts
Driving Power	2	2	2			Watts
Plate Power Output	76	87	130			Watts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR
(Key-down Conditions per Tube without Modulation)†

D-c Plate Voltage	1000	1250	1500	1250	1500	Volts
D-c Grid Voltage (Grid No. 1)	-70	-80	-90	-300	-300	Volts
D-c Grid Voltage (Grid No. 2)	300	300	300	400	400	Volts
Beam Forming Plate Voltage	0	0	0			Volts
D-c Plate Current	150	144	150	150	150	Milliamperes

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR (CONT'D)

	Typical Operation			Maximum Ratings		
	CCS		IC and AS	CCS	IC and AS	
D-c Grid Current, approx	10	10	10	15	15	Milliamperes
Plate Input				180	225	Watts
Screen Input				10	10	Watts
Plate Dissipation				50	65	Watts
Peak R-F Grid Input Voltage, approx	150	165	170			Volts
Driving Power, approx	1.35	1.5	1.5			Watts
Plate Power Output, approx	100	130	160			Watts

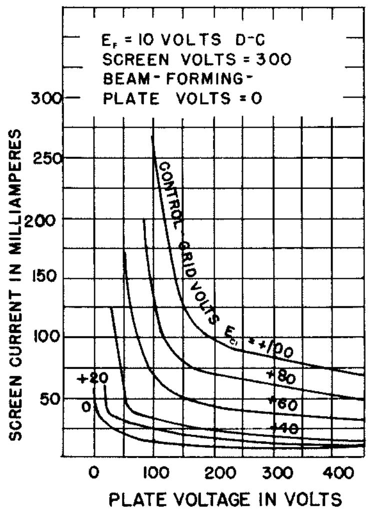
†Modulation, essentially negative, may be used if the positive peak of the Audio-Frequency envelope does not exceed 115 per cent of the carrier conditions.

The GL-814 can be operated at frequencies as high as 30 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 75 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

FREQUENCY	30	50	75	Megacycles
PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT				
Class B	100	90	85	Per cent
Class C Plate Modulated	100	80	64	Per cent
Class C Unmodulated	100	80	64	Per cent
Class C Grid Modulated	100	90	85	Per cent

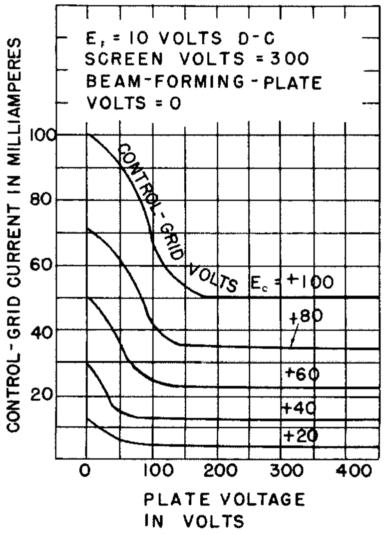
GL-814

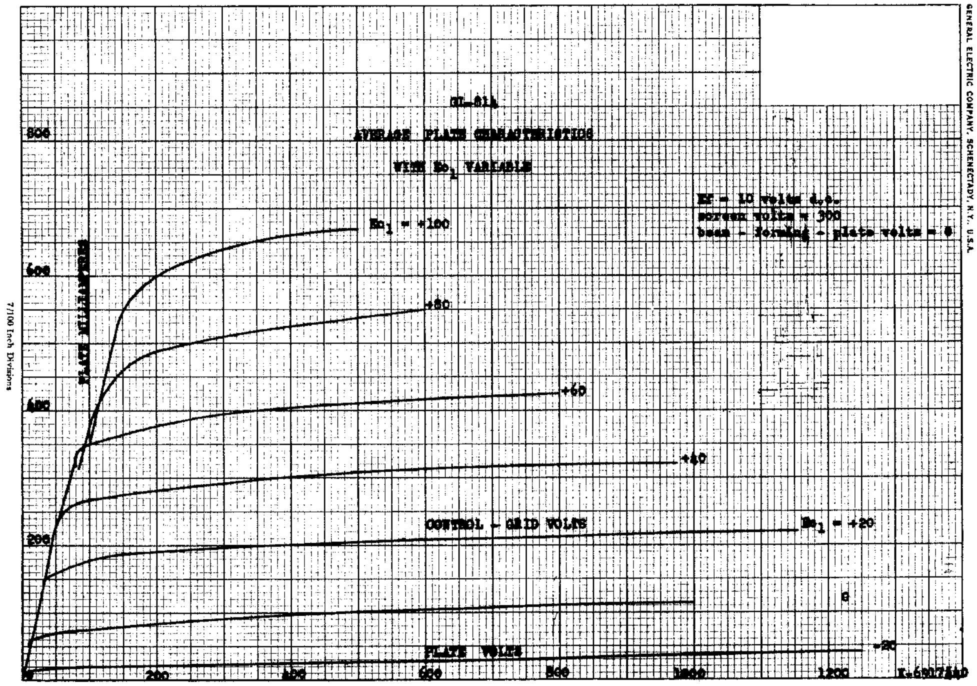
AVERAGE CHARACTERISTICS

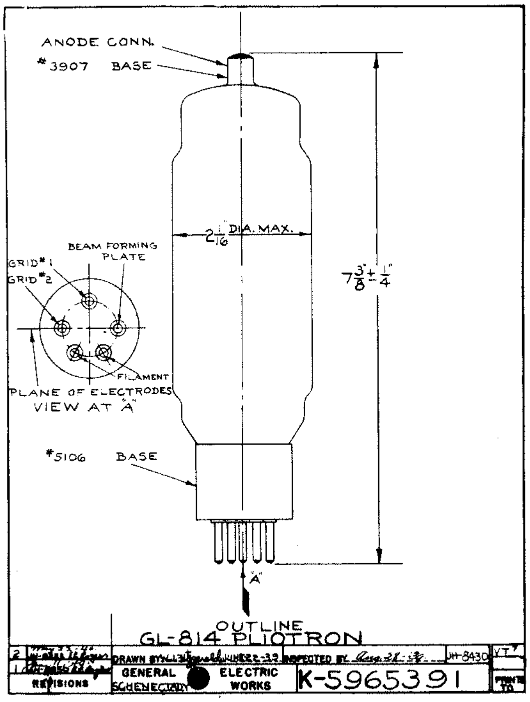


GL-814

AVERAGE CHARACTERISTICS







GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

3-44 (6M)
Filing No. 8850

Supersedes GET-950B

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-815--Description and Rating

DESCRIPTION

The 815 is a new push-pull beam transmitting tube designed especially for use in amateur bands from 160 meters to 2 1/2 meters. Neutralization is generally unnecessary in properly shielded circuits. The 815 contains in one envelope two beam power units whose total maximum plate dissipation is 25 watts. The high efficiency and exceptional power sensitivity of the 815 permit its operation at rated maximum input with very low driving power. For example, a single 815 operated in push-pull Class C telegraph service is capable of handling a power input of 75 watts (ICAS) with less than 0.2 watt of driving power.

The two units of the 815 may be used in push-pull arrangement as modulator, oscillator, or r-f amplifier, or separately, as single-ended amplifiers. Thus, the tube is well suited for use as a frequency multiplier and driver for another 815.

The exceptional efficiency of the 815 at the ultrahigh frequencies is made possible by the balanced and compact structure of the beam units, excellent internal shielding, and close electrode spacing. Internal leads are short in order to minimize internal lead inductance and resistance. The plate leads are brought to standard small metal caps; and the other leads are brought to an octal base. The heaters are arranged to allow operation from either a 12.6- or 6.3-volt supply.

Technical Information

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

ELECTRICAL

	Series	Parallel	
Cathode - Indirectly - heated			
Filament Voltage	12.6	6.3	Volts
Filament Current	0.8	1.6	Amperes
Grid-screen Amplification Factor		6.5	
Grid-plate Transconductance, for anode current of 25 ma		4000	Micromhos
Direct Interelectrode Capacitances, each unit			
Grid-plate, with external shielding		0.2	uuf
Input		14	uuf
Output		8.5	uuf

MECHANICAL

Base or Terminal Description	Large Wafer Octal 8-pin, Sleeve	
Net Weight, approx	3	ounces
Shipping Weight, approx	3	pounds
Installation and Operation	GEH-1205	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS AB_2 A-F POWER AMPLIFIER AND MODULATOR

	Typical Operation CCS	Typical Operation ICAS	Maximum Ratings CCS	Maximum Ratings ICAS	
Filament Voltage		6.3			Volts
D-c Plate Voltage	400	500	400	500	Volts
Max Signal Plate Current*			150	150	Milliamperes
D-c Max Signal Plate Input *			60	75	Watts
Max Signal Screen Input*			4.5	4.5	Watts
Plate Dissipation*			20	25	Watts

	Typical Operation		Maximum Ratings		
	CCS	ICAS	CCS	ICAS	
D-c Grid Voltage	-15	-15			Volts
D-c Screen Voltage	125	125	225	225	Volts
Peak A-f Grid-to-grid Voltage	60	60			Volts
Zero Signal Plate Current	20	22			Milliamperes
Max Signal Plate Current	150	150			Milliamperes
Max Signal Screen Current	32	32			Milliamperes
Max Signal Driving Power†, approx	0.36	0.36			Watts
Load Resistance, per plate	1550	2000			Ohms
Effective Load, plate-to-plate	6200	8000			Ohms
Max Signal Plate Power Output	42	54			Watts

CLASS B R-F POWER AMPLIFIER
(Carrier conditions per tube for use with a max modulation factor of 1.0)

Filament Voltage		6.3			Volts
D-c Plate Voltage	400	500	400	500	Volts
D-c Grid Voltage	-25	-25			Volts
D-c Screen Voltage	125‡	125‡	225	225	Volts
D-c Plate Current	75	75	75	75	Milliamperes
D-c Screen Current	4	3			Milliamperes
Plate Input			30	37.5	Watts
Screen Input			4.0	4.0	Watts
Plate Dissipation			20	25	Watts
Peak R-f Grid-to-grid Voltage	50	50			Volts
Driving Power§, approx	0.8	0.7			Watts
Plate Power Output	10.5	13			Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - GRID-MODULATED
(Carrier conditions per tube for use with a max modulation factor of 1.0)

Filament Voltage		6.3			Volts
D-c Plate Voltage	400	500	400	500	Volts
D-c Grid Voltage	-40	-40	-175	-175	Volts
D-c Screen Voltage	125‡	125‡	225	225	Volts
D-c Plate Current	75	75	75	75	Milliamperes
D-c Grid Current, approx	0.4	0.4			Milliamperes
D-c Screen Current	3	3			Milliamperes
Plate Input			30	37.5	Watts
Screen Input			4.0	4.0	Watts
Plate Dissipation			20	25	Watts
Peak R-f Grid-to-grid Voltage, approx	80	80			Volts
Peak A-f Grid Voltage	19	17			Volts
Driving Power§, approx	0.32	0.28			Watts
Plate Power Output	10.5	13			Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE-MODULATED
(Carrier conditions per tube for use with a max modulation factor of 1.0)

Filament Voltage		6.3			Volts
D-c Plate Voltage	325	400	325	400	Volts
D-c Grid Voltage of	-45	-45	-175	-175	Volts
From a grid resistor of∨	11250	15000			Ohms
D-c Screen Voltage			225	225	Volts
From a fixed supply of‡	165	175			Volts
From a series resistor of	10000	15000			Ohms
D-c Plate Current	123	150	125	150	Milliamperes
D-c Grid Current, approx	4	3	7	7	Milliamperes
D-c Screen Current	16	15			Milliamperes
Plate Input			40	60	Watts
Screen Input			4.0	4.0	Watts
Plate Dissipation			13.5	20	Watts

	Typical Operation CCS	Typical Operation ICAS	Maximum Ratings CCS	Maximum Ratings ICAS	
Peak R-f Grid-to-grid Voltage, approx	112	116			Volts
Driving Power, approx	0.2	0.16			Watts
Plate Power Output	30	45			Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
(Key down conditions per tube without modulation) π

	Typical Operation CCS	Typical Operation ICAS	Maximum Ratings CCS	Maximum Ratings ICAS	
Filament Voltage			6.3		Volts
D-c Plate Voltage	400	500	400	500	Volts
D-c Grid Voltage			-175	-175	Volts
From a fixed supply of	-45	-45			Volts
From a cathode resistor of	260	265			Ohms
From a grid resistor of ◊	10000	13000			Ohms
D-c Screen Voltage△			225	225	Volts
From a fixed supply of	145	200			Volts
From a series resistor of	15000	17500			Ohms
D-c Plate Current	150	150	150	150	Milliamperes
D-c Grid Current, approx	4.5	3.5	7	7	Milliamperes
D-c Screen Current	17	17			Milliamperes
Plate Input			60	75	Watts
Plate Dissipation			20	25	Watts
Screen Input			4.5	4.5	Watts
Peak R-f Grid-to-grid Voltage, approx	116	112			Volts
Driving Power, approx	0.23	0.18			Watts
Plate Power Output	44	56			Watts

* Averaged over any audio-frequency cycle of sine-wave form.

† Driver stage should be capable of supplying the grids of the AB_2 stage with the specified driving power at low distortion. The effective resistance per grid circuit of the class AB_2 stage should be kept below 500 ohms and the effective impedance at the highest desired response frequency should not exceed 700 ohms.

‡ In applications requiring the use of screen voltages above 135 volts, provision should be made for the adjustment of control-grid bias for each unit separately. The necessity for this adjustment at the lower screen voltages depends on the distortion requirements and on whether the plate-dissipation rating is exceeded at zero-signal plate current.

§ At crest of audio-frequency cycle with modulation factor of 1.0.

◊ The grid-circuit resistance should never exceed 15000 ohms total per tube, or 30000 ohms per unit. Any additional bias required must be supplied by a cathode resistor or a fixed supply.

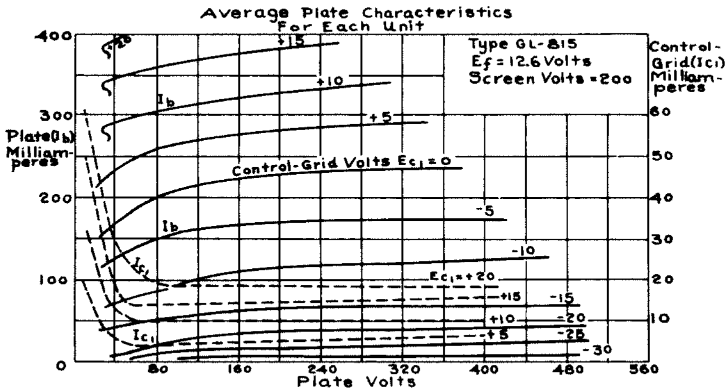
π Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

△ The screen voltage must not exceed 600 volts under key-up conditions.

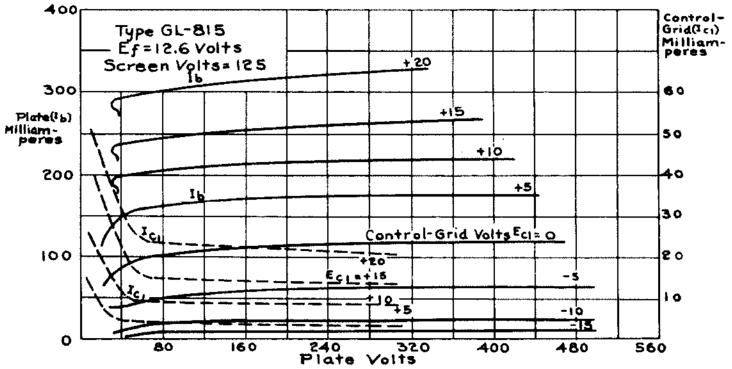
APPLICATION NOTES

The GL-815 can be operated at frequencies as high as 150 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 225 megacycles for the various classes of service. Special attention should be given to shielding, r-f by-passing, and adequate ventilation of the bulb at these frequencies.

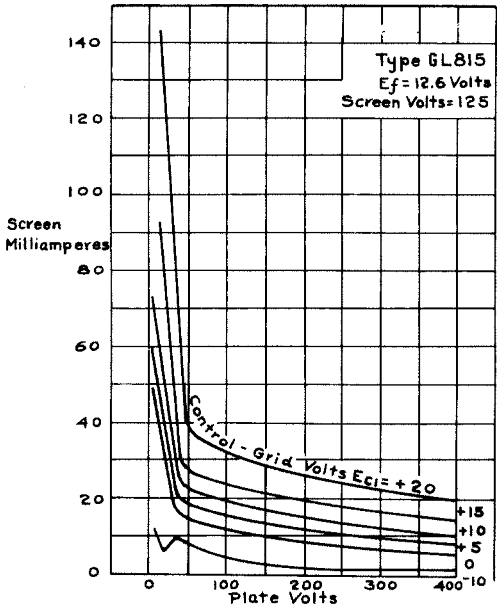
Frequency, megacycles	150	200	225
Max Permissible Percentage of Max Rated Plate Voltage and Plate Input			
Class B, R-f	100	85	75
Class C, Grid-modulated	100	85	75
Plate-modulated	100	80	70
Telegraphy	100	80	70



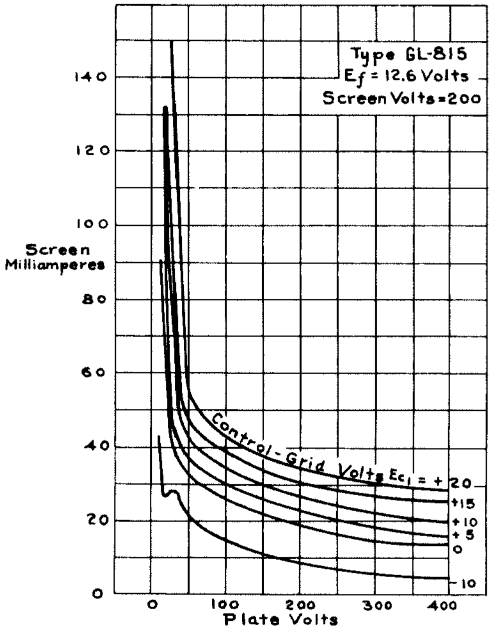
Average Plate Characteristics for Each Unit
K-6966446 3-22-41



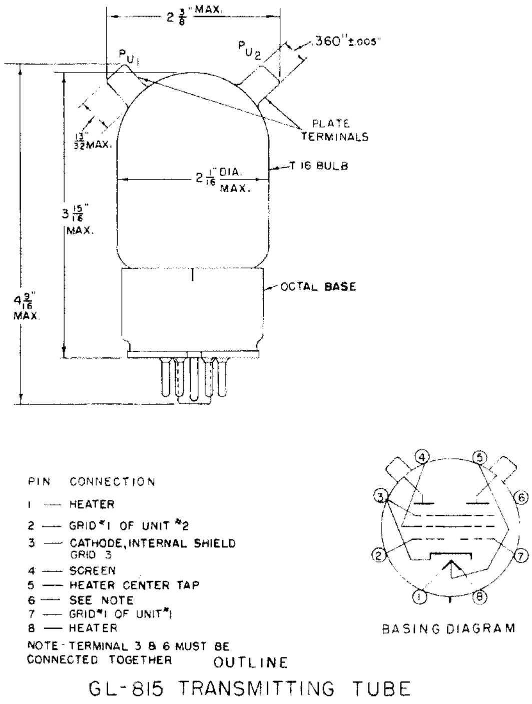
Average Plate Characteristics for Each Unit
K-6966443 3-22-41



Average Characteristics
for Each Unit
K-6966444 3-22-41



Average Characteristics
for Each Unit
K-6966447 3-22-41



Outline Transmitting Tube GL-815
K-6979116 3-20-41

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-816--Description and Rating

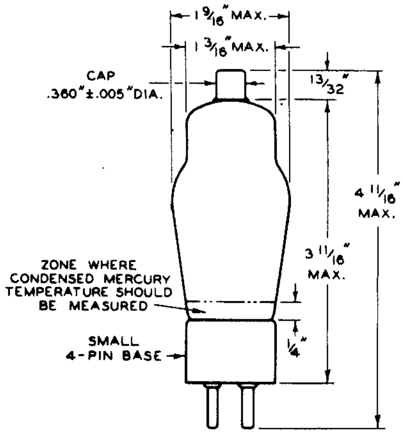
GL-816, a half-wave, mercury-vapor rectifier, is used in transmitting equipment where a tube with a lower power rating than the 866-A/866 is required. The maximum peak inverse voltage of 5000 volts and the peak plate current of 0.5 ampere are one-half the 866-A/866 values.

Two 816's operating in a full-wave rectifier circuit are capable of delivering to the input of a choke-input filter a rectified voltage of approximately 1600 volts at 0.25 ampere with good regulation.

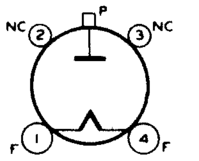
Technical Information

These data are for reference only; for design information see the specifications.

GENERAL DESIGN		
Number of Electrodes	2	
Cathode, Type		Filamentary
Voltage	2.5	Volts
Current, approx	2	Amperes
Heating Time, typical	10	Seconds
Tube Voltage Drop, approx	15	Volts
Cap		Small
Base		Small 4-pin
Net Weight, approx	3	Ounces
Shipping Weight, approx	3	Pounds
Installation and Operation	ET-H2	
MAXIMUM RATINGS		
Maximum Peak Inverse Anode Voltage		
150 Cycles per Second or Less	5000	Volts
Condensed Mercury Temperature		20 - 60 C
Maximum Anode Current		
Instantaneous	0.5	Ampere
Average	0.125	Ampere



Bottom View of Socket Connections



F = FILAMENT
P = PLATE
NC = NO CONNECTION

3-44 (10M)
Filing No. 8850

GENERAL ELECTRIC

Transmitting Tube GL-828 - - Description and Rating

Description

The 828 is a beam power amplifier tube designed particularly for use as a Class AB_1 audio-frequency amplifier. The high power sensitivity of the 828 allows it to be used in r-f services with very little driving power. Neutralization is generally unnecessary in properly shielded circuits.

Technical Information

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

ELECTRICAL

Number of Electrodes	5	
Filament Voltage	10	Volts
Filament Current	3.25	Amperes
Grid-plate Transconductance, for anode current of 43 ma	4500	Micromhos
Direct Interelectrode Capacitances		
Grid-plate, with external shielding	0.05	μμf
Input	13.5	μμf
Output	14.5	μμf

MECHANICAL

Base or Terminal Description	Medium 5-pin	
Net Weight, approx	3	Ounces
Shipping Weight, approx	3	Pounds
Installation and Operation	GEH-1254	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS AB_1 A-F POWER AMPLIFIER AND MODULATOR

	Typical Operation		Maximum Ratings Δ		
Filament Voltage		10			Volts
	CCS	IC & AS	CCS	IC & AS	
D-c Plate Voltage	1700	2000	1750	2000	Volts
D-c Suppressor Voltage	60	60	100	100	Volts
Max Signal Plate Current*			150	150	Milliamperes
D-c Max Signal Plate Input*			225	270	Watts
Screen Input*			16	23	Watts
Plate Dissipation*			70	80	Watts
D-c Grid Voltage†	-120	-120			Volts
D-c Screen Voltage‡	750	750	750	750	Volts
Peak A-f Grid-to-grid Voltage	240	240			Volts
Zero Signal Plate Current	50	50			Milliamperes
Max Signal Plate Current	248	270			Milliamperes
D-c Suppressor Current	9	9			Milliamperes
Zero Signal Screen Current	4	2			Milliamperes
Max Signal Screen Current	43	60			Milliamperes
Load Resistance, per plate	4050	4625			Ohms
Effective Load, plate-to-plate	16200	18500			Ohms
Max Signal Plate Power Output	300	385			Watts

CLASS B R-F POWER AMPLIFIER
(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation		Maximum Ratings△		
Filament Voltage	10				Volts
	CCS	IC & AS	CCS	IC & AS	
D-c Plate Voltage	1250	1500	1250	1500	Volts
D-c Suppressor Voltage	75	75	100	100	Volts
D-c Grid Voltage†	-50	-50			Volts
D-c Screen Voltage	400	400	400	400	Volts
D-c Plate Current	84	80	100	100	Milliamperes
D-c Suppressor Current	4	4			Milliamperes
D-c Screen Current	5	5			Milliamperes
Plate Input			105	120	Watts
Suppressor Input			5	5	Watts
Screen Input			11	11	Watts
Plate Dissipation			70	80	Watts
Peak R-f Grid-to-grid Voltage	52	50			Volts
Driving Power, approx§	0.5	0.4			Watt
Plate Power Output	36	41			Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - GRID-MODULATED
(Carrier conditions per tube for use with a max modulation factor of 1.0)

Filament Voltage	10				Volts
D-c Plate Voltage	1250	1500	1250	1500	Volts
D-c Suppressor Voltage	75	75	100	100	Volts
D-c Grid Voltage	-150	-150	-300	-300	Volts
D-c Screen Voltage	400	400	400	400	Volts
D-c Plate Current	84	80	100	100	Milliamperes
D-c Suppressor Current	4	3.5			Milliamperes
D-c Grid Current, approx	1.6	1.3			Milliamperes
D-c Screen Current	5	4			Milliamperes
Plate Input			105	120	Watts
Suppressor Input			5	5	Watts
Screen Input			11	11	Watts
Plate Dissipation			70	80	Watts
Peak R-f Grid-to-grid Voltage, approx	165	165			Volts
Peak A-f Grid Voltage	94	94			Volts
Driving Power, approx§	2.5	2.5			Watts
Plate Power Output	36	41			Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE-MODULATED
(Carrier conditions per tube for use with a max modulation factor of 1.0)

Filament Voltage	10				Volts
D-c Plate Voltage	1000	1250	1000	1250	Volts
D-c Suppressor Voltage	75	75	100	100	Volts
D-c Grid Voltage of	-140	-140	-300	-300	Volts
From a grid resistor of	14000	11700			Ohms
D-c Screen Voltage	400	400	400	400	Volts
From a series resistor of◊	26000	30000			Ohms
D-c Plate Current	135	160	135	160	Milliamperes
D-c Suppressor Current	13	15			Milliamperes
D-c Grid Current, approx	10	12	15	15	Milliamperes
D-c Screen Current	23	28			Milliamperes
Plate Input			135	200	Watts
Suppressor Input			5	5	Watts
Screen Input			11	11	Watts
Plate Dissipation			47	70	Watts

	Typical Operation		Maximum Ratings Δ		

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE-MODULATED (CONT'D)
(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation CCS	Typical Operation IC & AS	Maximum Ratings Δ CCS	Maximum Ratings Δ IC & AS	
Peak R-f Grid-to-grid Voltage, approx	230	250			Volts
Driving Power, approx	2.1	2.7			Watts
Plate Power Output	100	150			Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
(Key down conditions per tube without modulation)π

	Typical Operation CCS	Typical Operation IC & AS	Maximum Ratings Δ CCS	Maximum Ratings Δ IC & AS	
Filament Voltage			10		Volts
D-c Plate Voltage	1250	1500	1250	1500	Volts
D-c Suppressor Voltage	75	75	100	100	Volts
D-c Grid Voltage			-300	-300	Volts
From a fixed supply of	-95	-100			Volts
From a cathode resistor of	415	430			Ohms
From a grid resistor of	7900	8300			Ohms
D-c Screen Voltage	400	400	400	400	Volts
D-c Plate Current	160	180	160	180	Milliamperes
D-c Suppressor Current	22	14			Milliamperes
D-c Grid Current, approx	12	12	15	15	Milliamperes
D-c Screen Current	35	28			Milliamperes
Plate Input			200	270	Watts
Suppressor Input			5	5	Watts
Plate Dissipation			70	80	Watts
Screen Input			16	16	Watts
Peak R-f Grid-to-grid Voltage, approx	195	205			Volts
Driving Power, approx	2.1	2.2			Watts
Plate Power Output	150	200			Watts

* Averaged over any a-f cycle of sine wave form.

** Distortion only 1 per cent with 20 db of feedback to grid of driver.

† Grid voltages are given with respect to the midpoint of filament operated on a.c. If d.c. is used, each stated value of grid voltage should be decreased by one-half the filament voltage and the circuit returns made to the negative end of the filament.

‡ Zero-signal screen voltage must not exceed 775 volts.

§ At crest of audio-frequency cycle with modulation factor of 1.0.

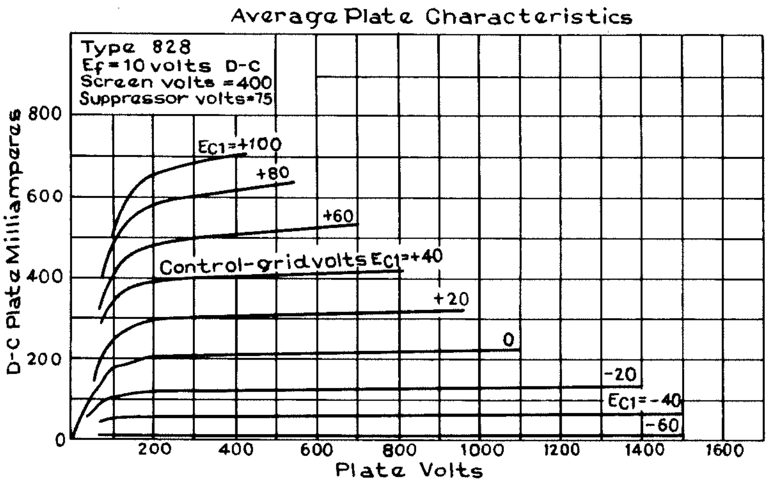
◊ Connected to modulated plate voltage supply.

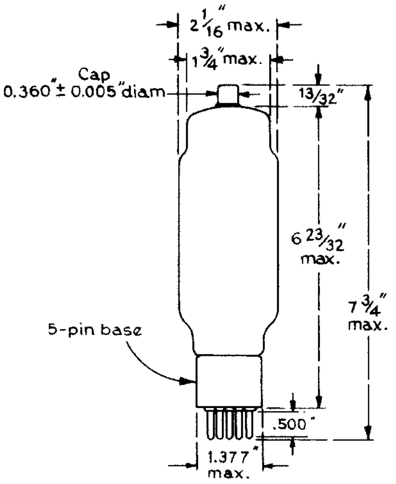
π Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

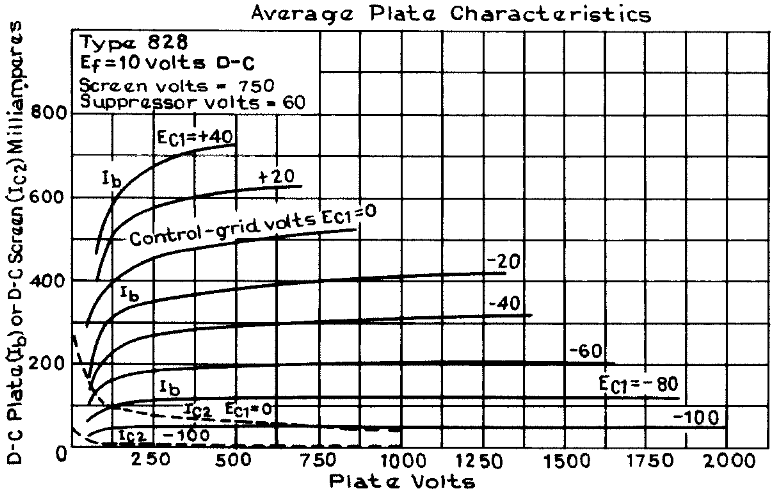
APPLICATION NOTES

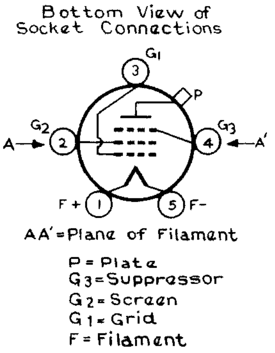
Δ The GL-828 can be operated at frequencies as high as 30 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 75 megacycles for the various classes of service. Special attention should be given to shielding, r-f by-passing, and adequate ventilation of the bulb at these frequencies.

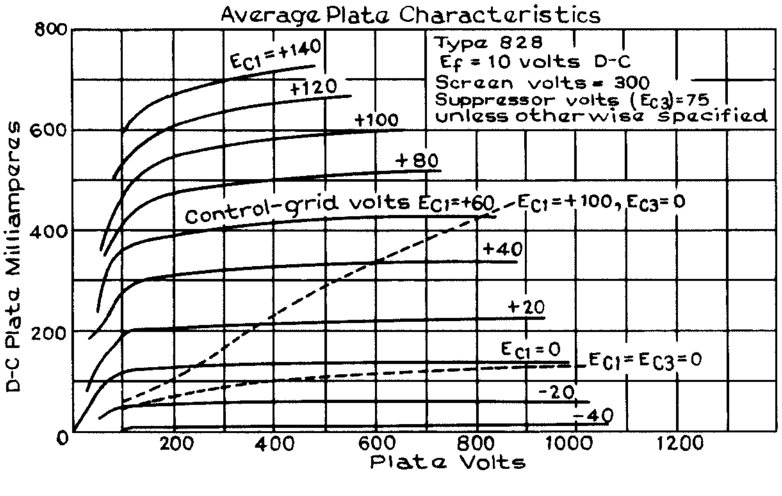
Frequency, megacycles	30	50	75
Max Permissible Percentage of Max Rated Plate Voltage and Plate Input			
Class B, R-f	100	90	80
Class C, Grid-modulated	100	90	80
Plate-modulated	100	80	65
Telegraphy	100	80	65

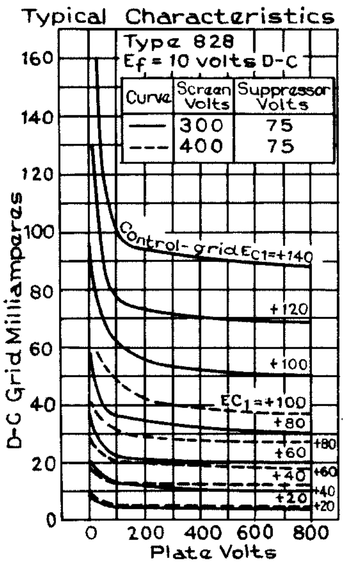












GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

2-42 (4M)
Filing No. 8850

PRINTED IN U.S.A.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-829-B--Description and Rating

The 829-B is a push-pull, beam power transmitting tube of the heater-cathode type. It contains two beam power units within one envelope. Total maximum plate dissipation is 40 watts. The exceptional efficiency and high power sensitivity of the 829-B permit full power output with very low driving power. For example, a single tube operated in push-pull Class C telegraph service is capable of handling a power input of 120 watts with less than a watt of driving power -- at frequencies as high as 200 mc (1 1/2 meters). The 829-B may be operated at reduced ratings at frequencies as high as 250 mc. Plate-to-plate circuit resonance of the tube is 750 megacycles.

The exceptional efficiency of the 829-B at the ultrahigh frequencies is made possible by the balanced and compact structure of the beam power units, excellent internal shielding, and close electrode spacing. The internal leads are short and heavy in order to minimize internal lead inductance. The terminal arrangement provides excellent insulation and is designed to facilitate symmetry of circuit layout. Neutralization of the tube is unnecessary in adequately shielded circuits.

The heaters are arranged to allow operation from either a 12.6- or a 6.3-volt supply.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

ELECTRICAL

	Series	Parallel	
Filament Voltage	12.6	6.3	Volts
Filament Current	1.125	2.25	Amp
Grid-plate Transconductance, I_b = 60 ma		8500	Mmhos
Grid-screen Amplification Factor		7	
Direct Interelectrode Capacitances, each unit			
Grid-plate (with external shielding)		0.1	uuf
Input		14.5	uuf
Output		7.0	uuf
Screen-cathode Capacitance, approx (including internal screen by-pass condenser)		65	uuf

MECHANICAL

Base Description - See outline	
Type of Cooling¶	Forced air
Net Weight, approx	3 1/2 Ounces
Shipping Weight, approx	3 Pounds
Installation and Operation - GEH-1189	

¶ Forced air cooling is not required in intermittent service where the ON period of plate power application is ordinarily not more than five minutes, and when the OFF period is not less than the ON period.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS C R-f POWER AMPLIFIER - GRID MODULATED

Carrier conditions per tube for use with a maximum modulation factor of 1.0

	Typical Operation		Max Ratings	
Filament Voltage		6.3		Volts
D-c Plate Voltage	500	750	750	Volts
D-c Grid Voltage*	-38	-55	-175	Volts
D-c Screen Voltage	200	200	225	Volts
D-c Plate Current	120	80	120	Ma
D-c Grid Current, approx	2	0		Ma
D-c Screen Current	10	5		Ma
Plate Input			60	Watts
Screen Input			6	Watts
Plate Dissipation			40	Watts
Peak R-f Grid Input Voltage, approx	82	104		Volts
Peak A-f Grid Voltage	17	15		Volts
Driving Power†, approx	0.5	0.7		Watts
Plate Power Output	23	24		Watts

CLASS C R-f POWER AMPLIFIER & OSCILLATOR - PLATE MODULATED

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Filament Voltage		6.3		Volts
D-c Plate Voltage	425	600	600	Volts
D-c Grid Voltage∆	-60	-70	-175	Volts
From a Grid Resistor† of			5500	Ohms
	5500	5800		Ohms

D-c Screen Voltage‡	200	200	225	Volts
	6400	13300		Ohms
D-c Plate Current	212	150	212	Ma
D-c Grid Current, approx	11	12	15	Ma
D-c Screen Current	35	30		Ma
Plate Input			90	Watts
Screen Input			7	Watts
Plate Dissipation			28	Watts
Peak R-f Grid Input Voltage, approx	154	172		Volts
Driving Power, approx	0.8	0.9		Watts
Plate Power Output	63	70		Watts

CLASS C R-f POWER AMPLIFIER & OSCILLATOR
Key-down conditions per tube without modulation§

Filament Voltage		6.3		Volts
D-c Plate Voltage	500	750	750	Volts
D-c Grid VoltageΔ◊	-45	-55	-175	Volts
	3750	4600		Ohms
	160	270		Ohms
D-c Screen Voltagesπ	200	200	225	Volts
	9300	18300		Ohms
D-c Plate Current	240	160	240	Ma
D-c Grid Current, approx	12	12	15	Ma
D-c Screen Current	32	30		Ma
Plate Input			120	Watts
Plate Dissipation			40	Watts
Screen Input			7	Watts
Peak R-f Grid Input Voltage, approx	124	140		Volts
Driving Power, approx	0.7	0.8		Watts
Plate Power Output	83	87		Watts

* Preferably obtained from a fixed supply, or may also be obtained from an unbypassed (for audio frequencies) cathode resistor.

† At crest of audio-frequency cycle with modulation factor of 1.0.

Δ The grid-circuit resistance should never exceed 15,000 ohms (total) per tube, or 30,000 ohms per unit. Any additional bias required must be supplied by a cathode resistor or a fixed supply.

‡ Obtained from a separate source modulated with the plate supply, or obtained from the modulated plate-voltage supply through a resistor of the value shown.

§ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

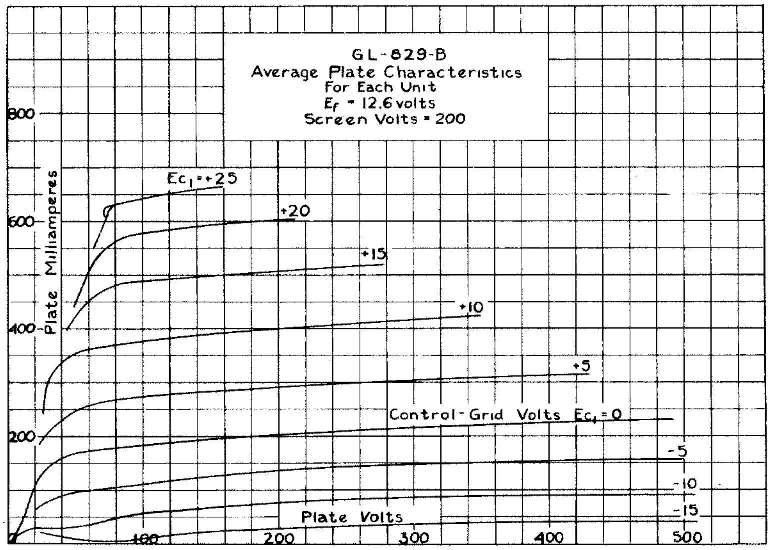
◊ Obtained from a fixed supply, by grid resistor (3750, 4600), or cathode resistor (160, 270).

π Obtained from a separate source, or from the plate voltage supply with a voltage divider, or through a series resistor of the value shown.

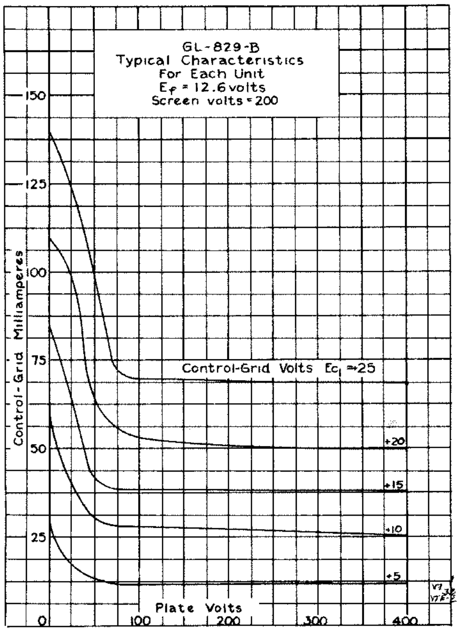
APPLICATION NOTES

The GL-829-B can be operated at frequencies as high as 200 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown above.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 250 megacycles for the various classes of service. Special attention should be given to shielding, cooling, and r-f by-passing at these frequencies.

Frequency, megacycles		200	250
Maximum Permissible Percentage of Maximum Rated Plate Voltage and Plate Input			
Class C	(grid-modulated	100	94
	(plate-modulated	100	89
	(telegraphy	100	89



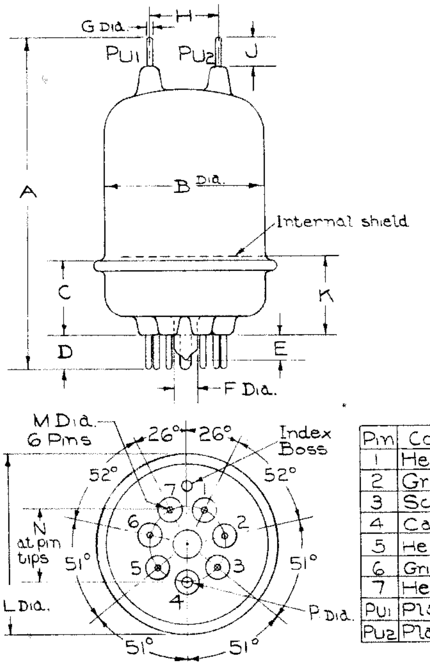
Average Plate Characteristics
K-6966430 12-15-44



Typical Characteristics
K-6966429 12-15-44

MOUNTING POSITION

VERTICAL - Plate terminals up or down
HORIZONTAL - Plane of each plate vertical (on edge)



Let.	Max.	Min.
A	4 5/16"	
B	2 1/16"	
C	1 1/32"	29/32"
D	1/2"	3/8"
E	3/8"	
F	3/8"	
G	.062"	.058"
H	7/8"	
J		3/8"
K	1"	
L	2 3/8"	
M	.062"	.058"
N	1.010"	.990"
P	.128"	.122"

Pin	Connections
1	Heater
2	Grid #1 of Unit #2
3	Screen
4	Cathode
5	Heater centertap
6	Grid #1 of Unit #1
7	Heater
Pu1	Plate of Unit #1
Pu2	Plate of Unit #2

Outline Transmitting Tube GL-829-B
K-6966966 12-15-44

GENERAL ELECTRIC
SCHENECTADY, N.Y.

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

12-44 (7M)
Filing No. 8850

Supersedes GET-965A

PRINTED IN U.S.A.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-830-B--Description and Rating

GL-830-B, a three-electrode transmitting tube, is used as a Class B modulator, radio-frequency amplifier, and oscillator. This tube, as a radio-frequency amplifier or oscillator, can be operated at maximum rated conditions at frequencies as high as 15 megacycles. For Class C telegraph and Class B services the plate dissipation is 60 watts. Two tubes of this type can deliver an output of 175 watts in Class B audio service.

These data are for reference only. For design information see the specifications.

TECHNICAL INFORMATION

GENERAL DESIGN

Filament Voltage	10 Volts
Filament Current	2 Amperes
Amplification Factor	25
Direct Interelectrode Capacitances, approx	
Grid-plate	11 uuf
Grid-filament	5 uuf
Plate-filament	1.8 uuf
Cap	Small Metal
Base or Terminal Description	Medium 4-pin Bayonet
Net Weight, approx	3 Ounces
Shipping Weight, approx	3 Pounds
Installation and Operation	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B A-F POWER AMPLIFIER (TWO TUBES)	Typical Operating Conditions		Maximum Ratings	
D-c Plate Voltage	800	1000	1000π	Volts
Maximum Signal Plate Current*			150π	Milliamperes
D-c Maximum Signal Plate Input*			150π	Watts
Plate Dissipation*			60π	Watts
D-c Grid Voltage	-27	-35		Volts
Peak A-F Grid-to-Grid Voltage	250	270		Volts
Zero Signal Plate Current	20	20		Milliamperes
Maximum Signal Plate Current	280	280		Milliamperes
Maximum Signal Driving Power, approx	5	6		Watts
Effective Load, plate-to-plate	6000	7600		Ohms
Maximum Signal Plate Power Output	135	175		Watts

CLASS B R-F POWER AMPLIFIER
Carrier conditions per tube for use with a maximum modulation factor of 1.0

Filament Voltage, a-c	10	10		Volts
D-c Grid VoltageΔ	-27	-35		Volts
D-c Plate Voltage	800	1000	1000π	Volts
D-c Plate Current	95	85	100π	Milliamperes

CLASS B R-F POWER AMPLIFIER (CONT'D)

Carrier conditions per tube for use with a maximum modulation factor of 1.0

	Typical Operating Conditions		Maximum Ratings	
Plate Input			90π	Watts
Plate Dissipation			60π	Watts
Peak R-F Grid Input Voltage	85	85		Volts
D-c Grid Current, approx§	7	6		Milliamperes
Driving Power, approx§†	9	6		Watts
Plate Power Output, approx	23	26		Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Filament Voltage, a-c	10	10		
D-c Plate Voltage	600	800	800π	Volts
D-c Grid Voltage	-140	-150	-300π	Volts
D-c Plate Current	95	95	100π	Milliamperes
D-c Grid Current, approx§	30	20	30π	Milliamperes
Plate Input			80π	Watts
Plate Dissipation			40π	Watts
Peak R-F Grid Input Voltage, approx	255	265		Volts
Driving Power, approx§	7	5		Watts
Plate Power Output	38	50		Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR

Key-down conditions per tube without modulation‡

	Typical Operating Conditions			Maximum Ratings	
Filament Voltage, a-c	10	10	10		
D-c Plate Voltage	600	800	1000	1000π	Volts
D-c Grid Voltage	-95	-105	-110	-300π	Volts
D-c Plate Current	140	140	140	150π	Milliamperes
D-c Grid Current, approx§	30	30	30	30π	Milliamperes
Plate Input				150π	Watts
Plate Dissipation				60π	Watts
Peak R-F Grid Input Voltage, approx	235	245	250		Volts
Driving Power, approx§	7	7	7		Watts
Plate Power Output, approx	45	70	90		Watts

π Per tube.

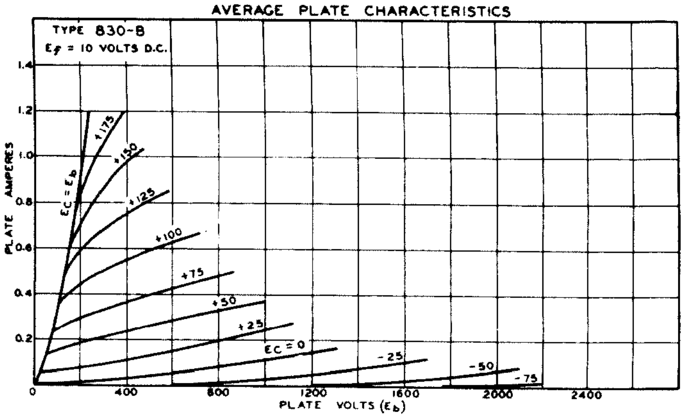
* Averaged over any audio-frequency cycle.

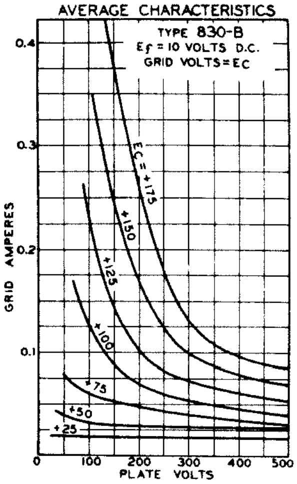
Δ Grid voltages are given with respect to the mid-point of filament operated on alternating current. If direct current is used, each stated value of grid voltage should be decreased by 5.0 volts and the circuit returns connected to the negative end of the filament.

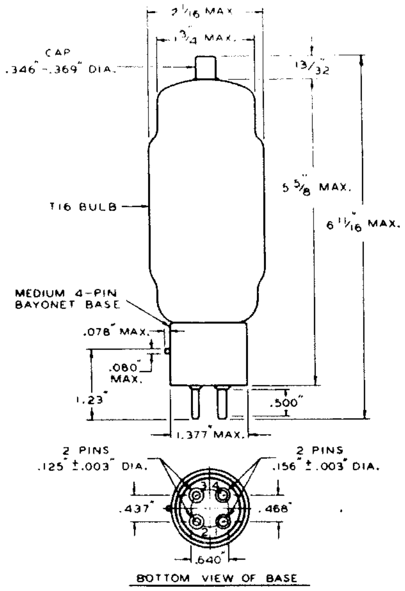
§ Subject to wide variations depending on the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits need less grid current and driving power, but plate-circuit efficiency is sacrificed. The driving stage should be capable of delivering considerably more than the required driving power.

† At crest of audio-frequency cycle.

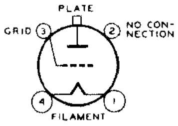
‡ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.







Top View of Socket Connections



ELECTRONICS DEPARTMENT
GENERAL ELECTRIC

Transmitting Tube GL-833-A--Description and Rating

GL-833-A is a three-electrode transmitting tube of the high-mu type for use as a radio-frequency amplifier, oscillator, and Class B modulator. Because of its high perveance, the 833-A can be operated at high plate efficiency with low-driving power.

Designed in a new way with post terminals which provide a sturdy structure and make bases unnecessary, the 833-A has a minimum amount of insulation within the tube. The anode is supported directly from its post terminal at the top of the tube. Short, heavy-current leads are used to connect the anode and the grid to their respective terminals in order to carry the high circulating r-f current at the high frequencies and to minimize internal lead inductance.

As a result of its construction, the 833-A provides exceptional efficiency at high frequencies. It can be operated in Class C telegraph service with maximum input of 2000 watts at frequencies as high as 30 megacycles, and with reduced input at frequencies as high as 75 megacycles.

Technical Information

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

ELECTRICAL

Number of Electrodes	3
Filament Voltage	10 volts
Filament Current	10 amperes
Amplification Factor	35
Direct Interelectrode Capacitances	
Grid-plate	6.3 uuf
Grid-to-filament	12.3 uuf
Plate-to-filament	8.5 uuf

MECHANICAL

Over-all dimensions	
Maximum Length	8 13/16 inches
Maximum Diameter	4 19/32 inches
Terminal Description	See Outline
Net Weight, approx	1 pound
Shipping Weight, approx	3 pounds
Installation and Operation	GEH-1190

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B A-F POWER AMPLIFIER (TWO TUBES)

	TYPICAL OPERATION			MAXIMUM RATINGS			
Filament Voltage			10				volts
	CCS	CCS *	ICAS *	CCS	CCS *	ICAS *	
D-c Plate Voltage	3000	4000	4000	3000	4000	4000	volts
Max Signal Plate Current, per tube†				500	500	500	ma

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B A-F POWER AMPLIFIER (TWO TUBES)

	TYPICAL OPERATION			MAXIMUM RATINGS			
	CCS		ICAS	CCS		ICAS	
		*	*		*	*	
D-c Max Signal Plate Input, per tube†				1125	1600	1800	watts
Plate Dissipation†, per tube				300	400	450	watts
D-c Grid Voltage ‡	-70	-100	-100				volts
Peak A-f Grid Input Voltage	400	480	510				volts
Zero Signal Plate Current	100	100	100				ma
Max Signal Plate Current	750	800	900				ma
Max Signal Driving Power, approx	20	29	38				watts
Effective Load, plate to plate	9500	12000	11000				ohms
Maximum Signal Plate Power Output, approx	1650	2400	2700				watts
Load Resistance, per tube	2375	3000	2750				ohms

CLASS B R-F POWER AMPLIFIER
(Carrier conditions per tube for use with a max modulation factor of 1.0)

Filament Voltage		*	*	10		*	*	volts
D-c Plate Voltage	3000	4000	4000		3000	4000	4000	volts
D-c Grid Voltage‡	-70	-120	-120					volts
D-c Plate Current	150	150	150		300	300	300	ma
Plate Input					450	600	675	watts
Plate Dissipation					300	400	450	watts
Peak R-f Grid Input Voltage	90	120	130					volts
Driving Power§Δ, approx	10	14	21					watts
Plate Power Output, approx	150	225	250					watts
D-c Grid Current, approxΔ	2	2	3					ma

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED
(Carrier conditions per tube for use with a max modulation factor of 1.0)

Filament Voltage		*	*	10		*	*	volts
D-c Plate Voltage	2500	3000	4000		2500	3000	4000	volts
D-c Grid Voltageπ	-300	-300	-325		-500	-500	-500	volts
	4000	3600	3600					ohms
D-c Plate Current	335	415	450		400	450	450	ma
D-c Grid Current, approx	75Δ	85Δ	90Δ		100	100	100	ma
Plate Input					835	1250	1800	watts
Plate Dissipation					200	270	350	watts
Driving PowerΔ , approx	30	37	42					watts
Plate Power Output, approx	635	1000	1500					watts
Peak R-f Grid Voltage	460	490	520					volts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
(Key down conditions per tube without modulation)◊

Filament Voltage		*	*	10		*	*	volts
D-c Plate Voltage	3000	4000	4000		3000	4000	4000	volts
D-c Grid Voltage#	-200	-200	-225		-500	-500	-500	volts
	3500	2650	2400					ohms
	425	380	380					ohms
D-c Plate Current	415	450	500		500	500	500	ma
D-c Grid Current, approx	55Δ	75Δ	95Δ		100	100	100	ma
Plate Input					1250	1800	2000	watts
Plate Dissipation					300	400	450	watts
Peak R-f Grid Input Voltage, approx	360	375	415					volts
Driving PowerΔ, approx	20	26	35					watts
Plate Power Output, approx	1000	1440	1600					watts

* Forced-air cooling required at these conditions of operation. When forced-air cooling is required an air flow of 40 cfm from a two-inch diameter nozzle directed vertically downward on bulb between grid and plate seals is required. Bulb temperature between grid and plate seals must not exceed 145 C. For conditions of operation where forced-air cooling is not required, adequate free circulation of air around the tube is necessary for satisfactory operation.

† Averaged over any audio-frequency cycle of sine-wave form.

‡ For a-c filament supply.

§ At crest of audio-frequency cycle.

Δ Subject to wide variations depending on the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits need less grid current and driving power, but plate circuit efficiency is sacrificed. The driving stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.

π Obtained by grid resistor of value shown or by partial self-bias methods.

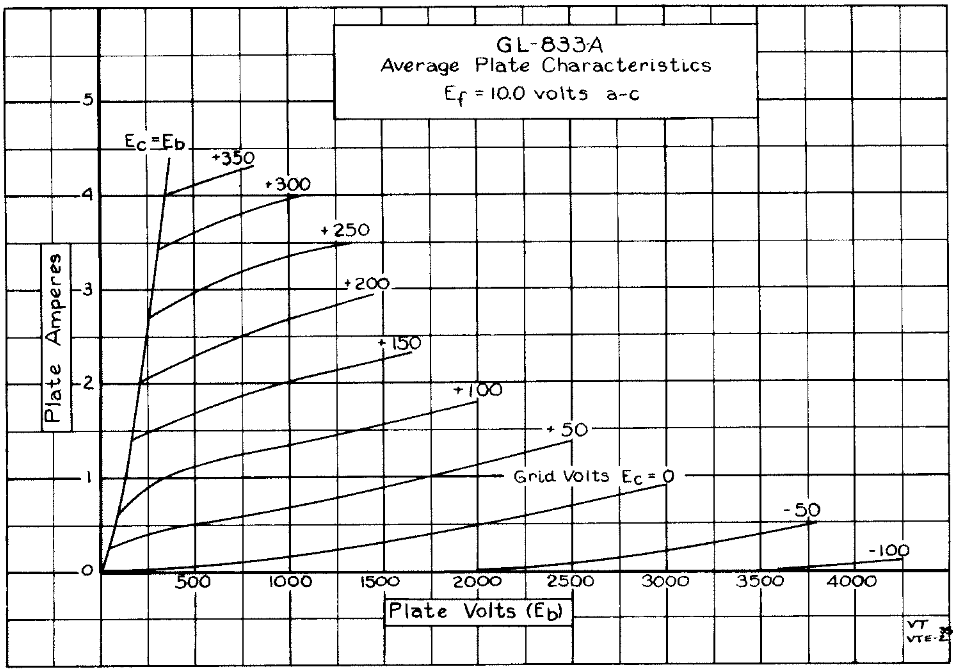
◊ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

Obtained from fixed supply, by grid resistor (3500, 2650, 2400), or by cathode resistor (425, 380, 380).

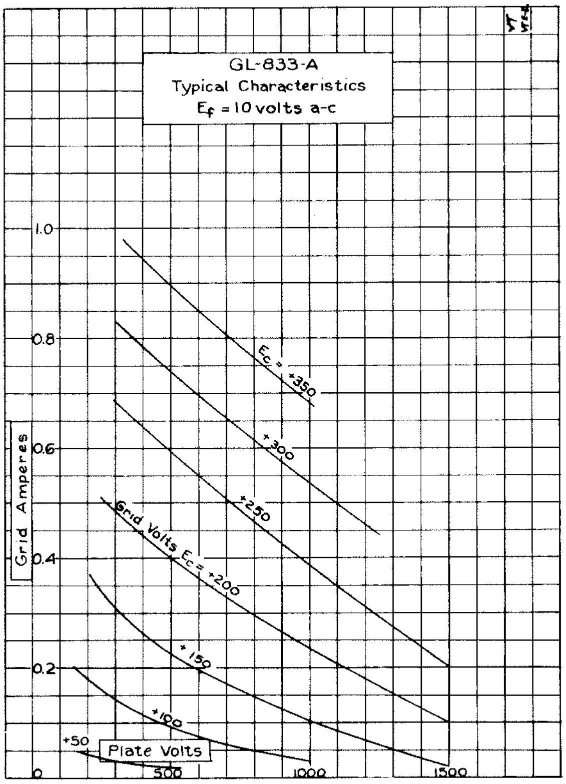
APPLICATION NOTES

The GL-833-A can be operated at frequencies as high as 30 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 100 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

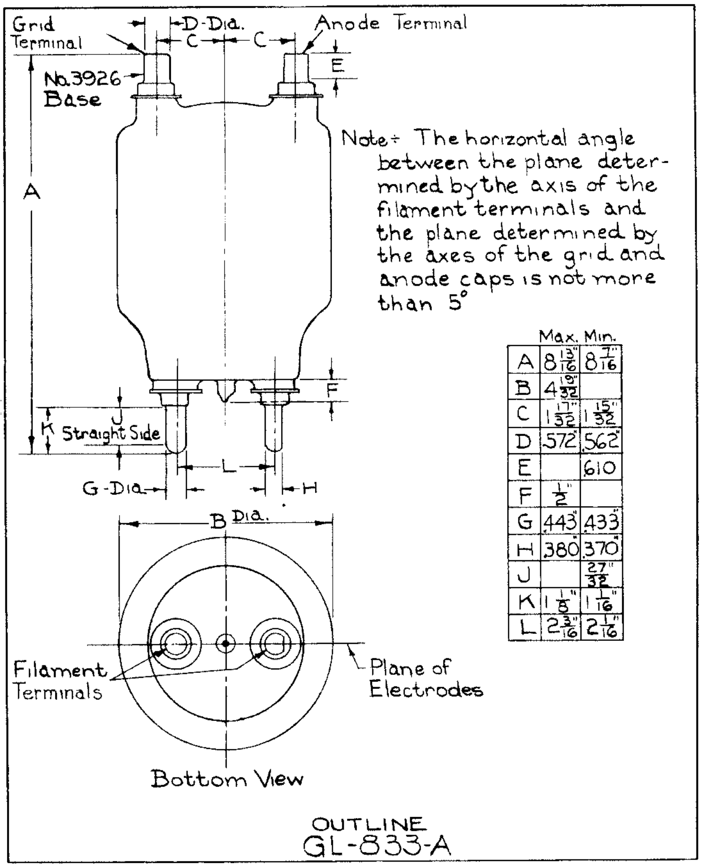
	Natural Cooling			Forced-air Cooling		
Frequency, megacycles	30	50	75	20	50	75
Maximum Permissible Percentage of Maximum Rated Plate Voltage and Plate Input						
Class B, r-f	100	98	94	100	97	93
Class C, plate-modulated	100	90	72	100	83	65
Class C	100	90	72	100	83	65



Average Plate Characteristics
K-6966408 9-12-40



Typical Characteristics
K-6966409 9-12-40



	Max.	Min.
A	8 13/16"	8 7/16"
B	4 19/32"	
C	1 17/32"	1 15/32"
D	.572"	.562"
E		.610"
F	1/2"	
G	.443"	.433"
H	.380"	.370"
J		27/32"
K	1 1/8"	1 1/16"
L	2 3/16"	2 1/16"

Outline Transmitting Tube GL-833-A
K-6966950 10-1-40

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

2-44 (8M)
Filing No. 8850

Supersedes GET-963A
Printed in U.S.A.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-835--Description and Rating

The 835 is a three-electrode transmitting tube for use as an oscillator, radio-frequency amplifier, and audio-frequency amplifier or modulator (Class A or B).

TECHNICAL INFORMATION

These data are for reference only. For design information see specifications.

Filament Voltage	10.0	Volts
Filament Current	3.25	Amperes
Amplification Factor	12	
Grid-plate Transconductance (I_b = 60 ma)	3600	Micromhos
Direct Interelectrode Capacitances:		
Grid-plate	9.25	uuf
Input	6	uuf
Output	5	uuf
Base or Terminal Description	Jumbo 4-large Pin	
Frequency for Maximum Ratings	20	Megacycles
Net Weight (approx)	8	Ounces
Shipping Weight (approx)	3	Pounds

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS A A-F AMPLIFIER AND MODULATOR

D-c Plate Voltage	750	1000	1250	1250 max	Volts
Plate Dissipation				75 max	Watts
D-c Grid Voltage	-41	-56	-75		Volts
Peak Grid Swing (approx)	41	56	75		Volts
D-c Plate Current	.034	.053	.060		Ampere
Plate Resistance	4400	3800	3600		Ohms
Load Resistance	8800	7600	9200		Ohms
Plate Power Output (5 per cent second harmonic)	5.6	12	19.7		Watts

CLASS B A-F POWER AMPLIFIER (TWO TUBES):

D-c Plate Voltage	1000	1250	1250 max	Volts
Max Signal Plate Current (per tube)*			0.175	Ampere
D-c Maximum Signal Plate Input (per tube)*			220 max	Watts
Plate Dissipation (per tube)*			100 max	Watts
D-c Grid Voltage	-72	-95		Volts
Peak A-f Grid Input Voltage	380	410		Volts
Zero Signal Plate Current	.020	.020		Ampere
Maximum Signal Plate Current	.320	.320		Ampere
Maximum Signal Driving Power (approx)	7.5	8		Watts
Effective Load (plate-to-plate)	6900	9000		Ohms
Maximum Signal Plate Power Output	200	260		Watts

CLASS B R-F POWER AMPLIFIER
Carrier conditions per tube for use with a maximum modulation factor of 1.0

D-c Plate Voltage	1000	1250	1250 max	Volts
D-c Grid Voltage	-72	-95		Volts
D-c Plate Current	0.130	0.106	0.150 max	Ampere
Plate Input			150 max	Watts
Plate Dissipation			100 max	Watts
Peak R-f Grid Voltage	125	125		Volts
D-c Grid Current (approx)	5	1		Milliamperes
Driving Power (approx)**	10	7.5		Watts
Plate Power Output	40	42.5		Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED
Carrier conditions per tube for use with a maximum modulation factor of 1.0

D-c Plate Voltage	750	1000	1000 max	Volts
D-c Grid Voltage	-200	-260	-400 max	Volts
D-c Plate Current	0.150	0.150	0.175 max	Ampere
D-c Grid Current (approx)	0.035	0.035	0.050 max	Ampere
Plate Input			175 max	Watts
Plate Dissipation			67 max	Watts
Peak R-f Grid Input Voltage (approx)	350	410		Volts
Driving Power (approx)	12	14		Watts
Plate Power Output	65	100		

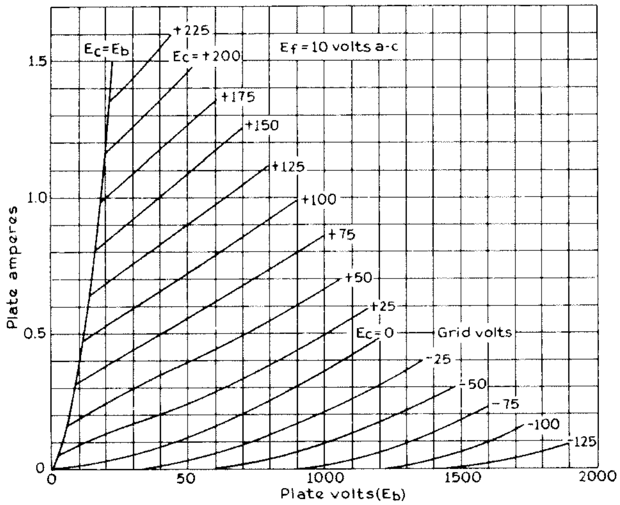
CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
Key-down conditions per tube with modulation†

D-c Plate Voltage	750	1000	1250	1250 max	Volts
D-c Grid Voltage	-135	-175	-225	-400 max	Volts
D-c Plate Current	0.150	0.150	0.150	0.175 max	Ampere
D-c Grid Current (approx)	0.018	0.018	0.018	0.050 max	Ampere
Plate Input				220 max	Watts
Plate Dissipation				100 max	Watts
Peak R-f Grid Input Voltage (approx)	275	315	375		Volts
Driving Power (approx)	5	6	7		Watts
Plate Power Output	65	100	130		Watts

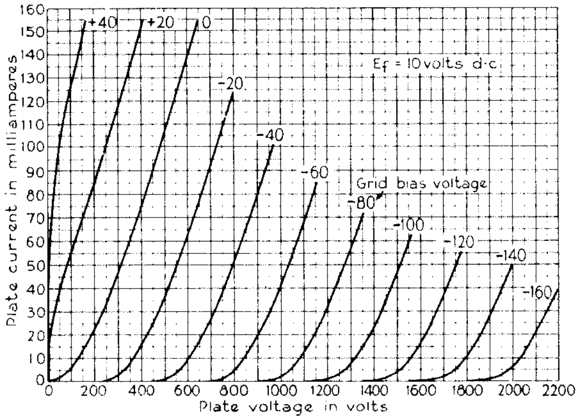
* Averaged over an audio-frequency cycle.
** At crest of audio-frequency cycle.
† Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

GL-835 can be operated at maximum ratings in all classes of service at frequencies as high as 20 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under TECHNICAL INFORMATION.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 100 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

FREQUENCY	20	40	100	Mc
MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT:				
Class B Telephony	100	85	70	Per Cent
Class C (Telephony, plate-modulated (Telegraphy	100	80	50	Per Cent



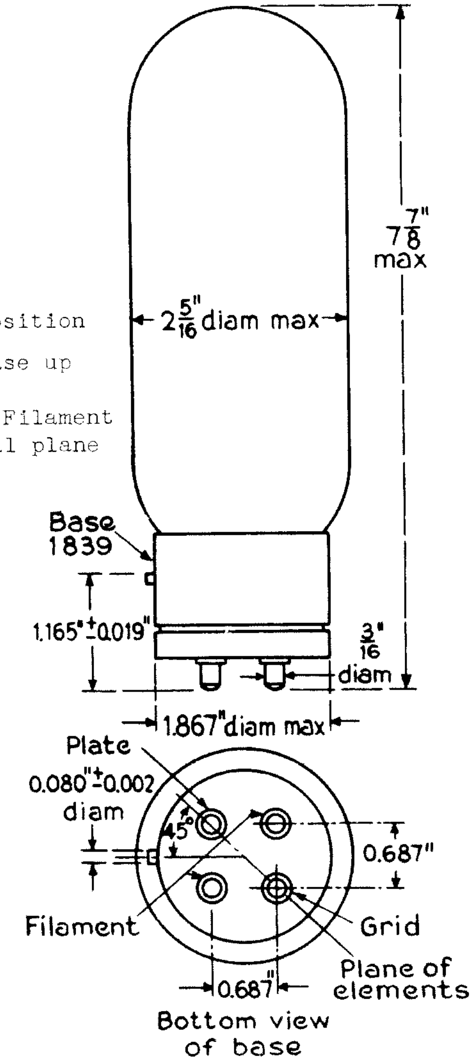
Average Plate Characteristics
for Transmitting Tube GL-835
K-6917437 11-6-39



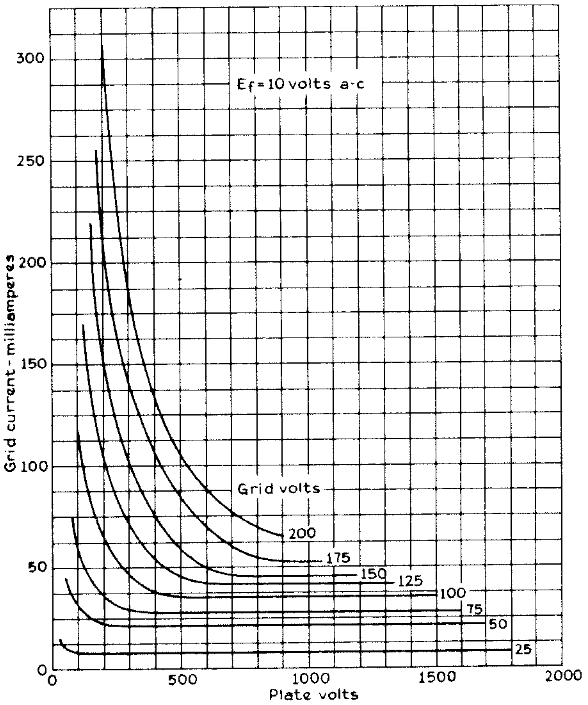
Average Plate Characteristics
for Transmitting Tube GL-835
K-6917423 10-3-39

Mounting Position

Vertical: Base up
or down
Horizontal: Filament
in vertical plane
on edge.



Outline Transmitting Tube GL-835
K-4909036 8-6-43



Average Characteristics for
Transmitting Tube GL-835
K-6917435 11-6-39

GENERAL ELECTRIC

Transmitting Tube GL-836 - - Description and Rating

Description

The GL-836 is a half-wave, high-vacuum rectifier with two separate cathodes each of which is connected to its respective heater. The excellent voltage regulation characteristic of this tube is due to the close spacing of the cathode and plate. The double-cathode construction and the close spacing of the electrodes result in a tube with excellent voltage regulation characteristics.

Technical Information

These data are for reference only. For equipment design see the specifications.

GENERAL CHARACTERISTICS

ELECTRICAL

Cathode - Indirectly Heated	
Voltage	2.5 Volts
Current	5.0 Amperes
Heating Time (Before applying plate voltage)	40 Seconds
Tube Voltage Drop, Approximate (See Curve), Ib = 250 ma	45 Volts

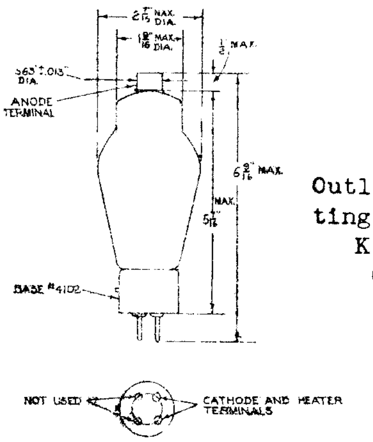
MECHANICAL

Type of Cooling - Convection (Maximum Ambient 60 C)	
Base Description	Medium 4-Pin Bayonet
Cap	Medium
Maximum Over-all Dimensions (See Outline)	
Length	6 9/16 Inches
Diameter	2 7/16 Inches
Mounting Position	Vertical or Horizontal
Net Weight, Approximate	3 Ounces

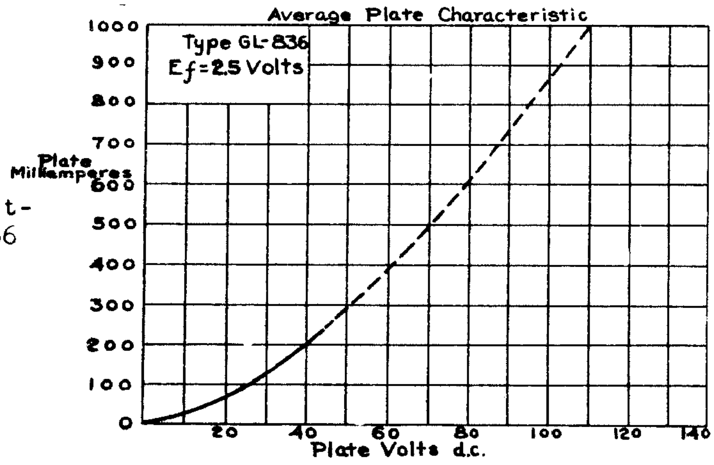
MAXIMUM RATINGS

RECTIFIER OPERATION

Peak Inverse Voltage	5000 Volts
Peak Plate Current	1.0 Ampere
Average Plate Current	0.25 Ampere



Outline Transmitting Tube GL-836
K-6979115
6-9-43



K-6966445 Average Plate Characteristics 3-22-41

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

8-43 (4M)
Filing No. 8850

Supersedes GET-972

PRINTED IN U.S.A.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-837 - - Description and Rating

The 837 is a pentode transmitting tube of the heater-cathode type for use as an r-f amplifier, frequency-multiplier, oscillator, and suppressor-, grid- or plate-modulated amplifier. The plate connection is brought out through a separate seal at the top of the bulb to maintain low grid-plate capacitance. Neutralization is generally unnecessary in adequately shielded circuits. The suppressor and the special internal shield are connected to individual base pins. The 837 may be operated at maximum ratings at frequencies as high as 20 megacycles. The maximum plate dissipation is 12 watts.

These data are for reference only. For design information see the specifications.

CHARACTERISITCS AND RATINGS

Heater Voltage, a-c or d-c	12.6	Volts
Heater Current	0.7	Ampere
Transconductance, for plate current of 24 ma	3400	Micromhos
Direct Interelectrode Capacitances:		
Grid-plate, with external shielding	0.20 max	μμf
Input	16	μμf
Output	10	μμf
Cap	Small Metal	
Base	Medium 7-pin Bayonet	
Net Weight, approx	5	Ounces
Shipping Weight, approx	3	Pounds
Installation and Operation	GEH-1106	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

	Typical Operation			Maximum Ratings	
AS R-F POWER AMPLIFIER PENTODE - CLASS B TELEPHONY					
Carrier conditions per tube for use with a max modulation factor of 1.0					
D-c Plate Voltage	400	500	500	500	Volts
D-c Suppressor Voltage,grid No. 3	0	0	40	200	Volts
D-c Screen Voltage, grid No. 2	200	200	200	200	Volts
D-c Grid Voltage, grid No. 1	-25	-25	-25		Volts
D-c Plate Current	35	30	30	40	Milliamperes
D-c Screen Current	10	15	12		Milliamperes
D-c Grid Current, approx	1	0	0		Milliampere
Peak R-f Grid Voltage	28	25	24		Volts
Internal Shield	Connected to cathode at socket				
Plate Input				16	Watts
Suppressor Input				5	Watts
Screen Input				5	Watts
Plate Dissipation				12	Watts
Driving Power, approx*	0.4	0.2	0.1		Watt
Power Output, approx	4	5	5.5		Watts
AS SUPPRESSOR-MODULATED R-F POWER AMPLIFIER - CLASS C TELEPHONY					
Carrier conditions per tube for use with a max modulation factor of 1.0					
D-c Plate Voltage		400	500	500	Volts
D-c Suppressor Voltage, grid No. 3		-55	-65		Volts
D-c Grid Voltage**		-20	-20	-200	Volts
D-c Screen Voltage, grid No. 2				200	Volts
Peak R-f Grid Voltage		45	32		Volts

	Typical Operation			Maximum Ratings	
Peak A-f Suppressor Voltage		55	65		Volts
Internal Shield	Connected to cathode at socket				
D-c Plate Current		35	30	40	Milliamperes
D-c Screen Current		37	23		Milliamperes
D-c Grid Current, approx		8	3.5	8	Milliamperes
Plate Input				16	Watts
Screen Input				8	Watts
Plate Dissipation				12	Watts
Screen Resistor		6500	14000		Ohms
Grid Resistor		2500	5700		Ohms
Driving Power, approx		0.4	0.1		Watt
Power Output, approx		4	5		Watts

AS GRID-MODULATED R-F POWER AMPLIFIER PENTODE - CLASS C TELEPHONY
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	400	500	500	500	Volts
D-c Suppressor Voltage	0	0	40	200	Volts
D-c Screen Voltage	200	200	200	200	Volts
D-c Grid Voltage**	-50	-45	-43	-200	Volts
Peak R-f Grid Voltage	58	48	44		Volts
Peak A-f Grid Voltage	25	20	18		Volts
Internal Shield	Connected to cathode at socket				
D-c Plate Current	35	30	30	40	Milliamperes
D-c Screen Current	9	7	6		Milliamperes
D-c Grid Current, approx	1	0	0		Milliampere
Plate Input				16	Watts
Suppressor Input				5	Watts
Screen Input				5	Watts
Plate Dissipation				12	Watts
Driving Power, approx*	0.5	0.2	0.15		Watt
Power Output, approx	4	5	5.5		Watts

AS PLATE-MODULATED R-F POWER AMPLIFIER PENTODE - CLASS C TELEPHONY
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	400	400	Volts
D-c Suppressor Voltage	40	200	Volts
D-c Screen Voltage	140	200	Volts
D-c Grid Voltage**	-40	-200	Volts
Peak R-f Grid Voltage	60		Volts
Internal Shield	Connected to cathode at socket		
D-c Plate Current	45	50	Milliamperes
D-c Screen Current	20		Milliamperes
D-c Grid Current, approx	5	8	Milliamperes
Plate Input		20	Watts
Suppressor Input		5	Watts
Screen Input		5	Watts
Plate Dissipation		8	Watts
Screen Resistor#	13000		Ohms
Grid Resistor	8000		Ohms
Driving Power, approx	0.3		Watt
Power Output, approx	11		Watts

AS PLATE-MODULATED R-F POWER AMPLIFIER TETRODE - CLASS C TELEPHONY
(Grids No. 2 and 3 connected together)
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	400	400	Volts
D-c Screen Voltage	100	200	Volts
D-c Grid Voltage**	-70	-200	Volts
Peak R-f Grid Voltage	100		Volts

	Typical Operation	Maximum Ratings	
Internal Shield	Connected to cathode at socket		
D-c Plate Current	45	50	Milliamperes
D-c Screen Current	30		Milliamperes
D-c Grid Current, approx	7	8	Milliamperes
Plate Input		20	Watts
Screen Input, grids No. 2 and 3		7.5	Watts
Plate Dissipation		8	Watts
Screen Resistor##	10,000		Ohms
Grid Resistor	10,000		Ohms
Driving Power, approx	0.7		Watt
Power Output, approx	11		Watts

AS R-F POWER AMPLIFIER AND OSCILLATOR PENTODE - CLASS C TELEGRAPHY
Key-down conditions per tube without modulation‡

D-c Plate Voltage	400	500	500	500	Volts
D-c Suppressor Voltage	0	0	40	200	Volts
D-c Screen Voltage	200	200	200	200	Volts
D-c Grid Voltage**	-40	-85	-75	-200	Volts
Peak R-f Grid Voltage	70	120	100		Volts
Internal Shield	Connected to cathode at socket				
D-c Plate Current	70	60	60	80	Milliamperes
D-c Screen Current	32	30	15		Milliamperes
D-c Grid Current, approx	8	8	4	8	Milliamperes
Plate Input				32	Watts
Suppressor Input				5	Watts
Screen Input				8	Watts
Plate Dissipation				12	Watts
Screen Resistor	6300	10000	20000		Ohms
Grid Resistor	5000	10600	18700		Ohms
Driving Power, approx	0.5	0.8	0.4		Watt
Power Output, approx	16	20	22		Watts

AS R-F POWER AMPLIFIER AND OSCILLATOR TETRODE - CLASS C TELEGRAPHY
(Grids No. 2 and 3 connected together)
Key-down conditions per tube without modulation‡

D-c Plate Voltage	400	500	500	Volts
D-c Screen Voltage	110	80	200	Volts
D-c Grid Voltage**	-70	-70	-200	Volts
Peak R-f Grid Voltage	115	110		Volts
Internal Shield	Connected to cathode at socket			
D-c Plate Current	70	60	80	Milliamperes
D-c Screen Current	25	15		Milliamperes
D-c Grid Current, approx	8	8	8	Milliamperes
Plate Input			32	Watts
Screen Input, grids No. 2 and 3			8	Watts
Plate Dissipation			12	Watts
Screen Resistor	11600	28000		Ohms
Grid Resistor	8700	8700		Ohms
Driving Power, approx	0.75	0.7		Watt
Power Output, approx	18	20		Watts

* At crest of audio-frequency cycle with modulation factor of 1.0.

** The total effective grid-circuit resistance should not exceed 25000 ohms.

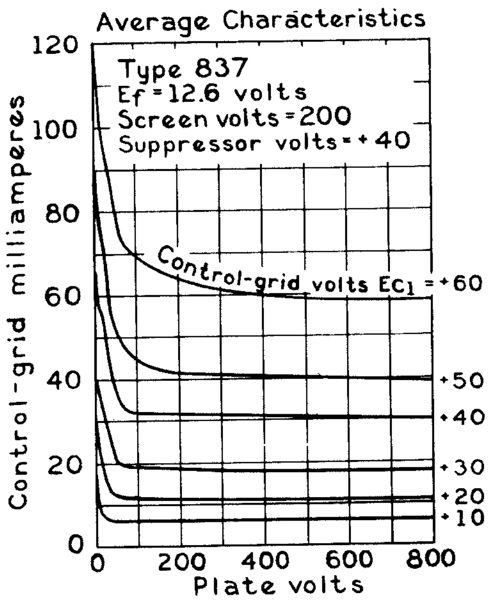
Connected to modulated plate-voltage supply.

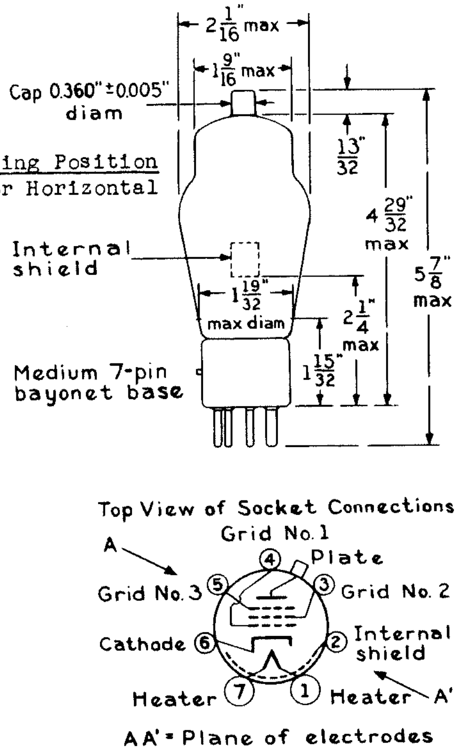
Connected to unmodulated plate-voltage supply.

‡ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

The maximum ratings apply only at frequencies below 20 megacycles. For operation at higher frequencies, adequate ventilation and normal ambient temperatures must be maintained, and the plate voltage must be reduced as indicated.

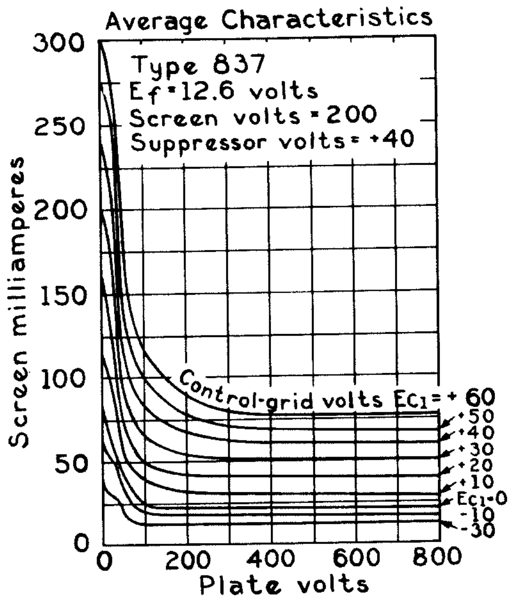
Frequency, Megacycles	20	40	60
Percentage of Maximum Rated Plate Voltage and Plate Input			
Class B, Class C Grid- or Suppressor-modulated	100	90	84
Class C Plate-modulated	100	76	62
Class C Telegraphy	100	76	62

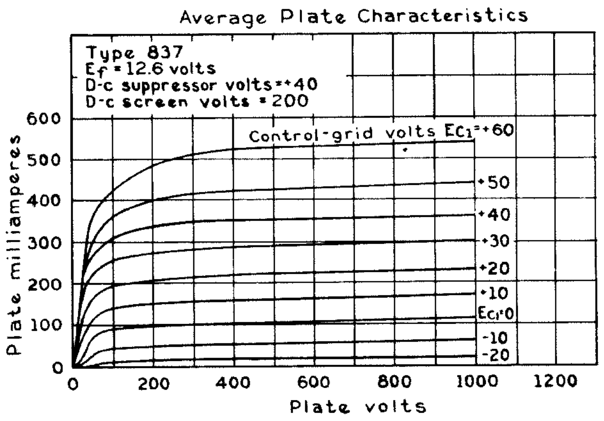




Tube Mounting Position

Vertical or Horizontal





GENERAL ELECTRIC

Transmitting Tube GL-838 - - Description and Rating

Technical Information

The 838, a high-mu, three-electrode tube, is especially designed for use as a zero-bias Class B audio-frequency power amplifier. The grid is designed so that the amplification factor of the tube varies with the amplitude of the input signal. This feature is particularly valuable in connection with the design of Class B amplifiers since it facilitates their ability to give high output with low distortion.

GENERAL CHARACTERISTICS

These data are for reference use only. For design information see the specifications.

Filament Voltage	10.0	Volts
Filament Current	3.25	Amperes
Direct Interelectrode Capacitances:		
Grid-plate	8	μμf
Input	6.5	μμf
Output	5	μμf
Base Description	Jumbo 4-large Pin	
Frequency for Maximum Ratings	30	Mc
Net Weight, approx	8	Oz
Shipping Weight, approx	7	lb
Installation and Operating Instructions	GEH-980	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

	Typical Operation		Maximum Rating	
CLASS B A-F POWER AMPLIFIER (TWO TUBES):				
D-c Plate Voltage	1000	1250	1250	Volts
Maximum Signal Plate Current, per tube*			175	Milliamperes
D-c Maximum Signal Plate Input, per tube*			220	Watts
Plate Dissipation, per tube*			100	Watts
D-c Grid Voltage	0	0		Volts
Peak A-f Grid Input Voltage	200	200		Volts
Zero Signal Plate Current	106	148		Milliamperes
Maximum Signal Plate Current	320	320		Milliamperes
Maximum Signal Plate Input*	320	400		Watts
Maximum Signal Driving Power, approx	7	7.5		Watts
Effective Load, plate-to-plate	6900	9000		Ohms
Maximum Signal Plate Power Output	200	260		Watts

CLASS B R-F POWER AMPLIFIER

Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	1000	1250	1250	Volts
D-c Grid Voltage	0	0		Volts
D-c Plate Current	130	106	150	Milliamperes
Plate Input			150	Watts
Plate Dissipation			100	Watts
Peak R-f Grid Input Voltage	70	60		Volts
D-c Grid Current, approx	15	15		Milliamperes
Driving Power, approx**	8	6		Watts
Plate Power Output	40	42.5		Watts

* Averaged over any audio-frequency cycle.

** At crest of audio-frequency cycle.

	Typical Operation		Maximum Rating	

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED
Carrier conditions per tube for use with a max modulation factor of 1.0

	Typical Operation		Maximum Rating	
D-c Plate Voltage	750	1000	1000	Volts
D-c Grid Voltage	-100	-135	-400	Volts
D-c Plate Current	150	150	175	Milliamperes
D-c Grid Current, approx	60	60	70	Milliamperes
Plate Input			175	Watts
Plate Dissipation			67	Watts
Peak R-f Grid Input Voltage, approx	220	255		Volts
Driving Power, approx	14	16		Watts
Plate Power Output	65	100		Watts

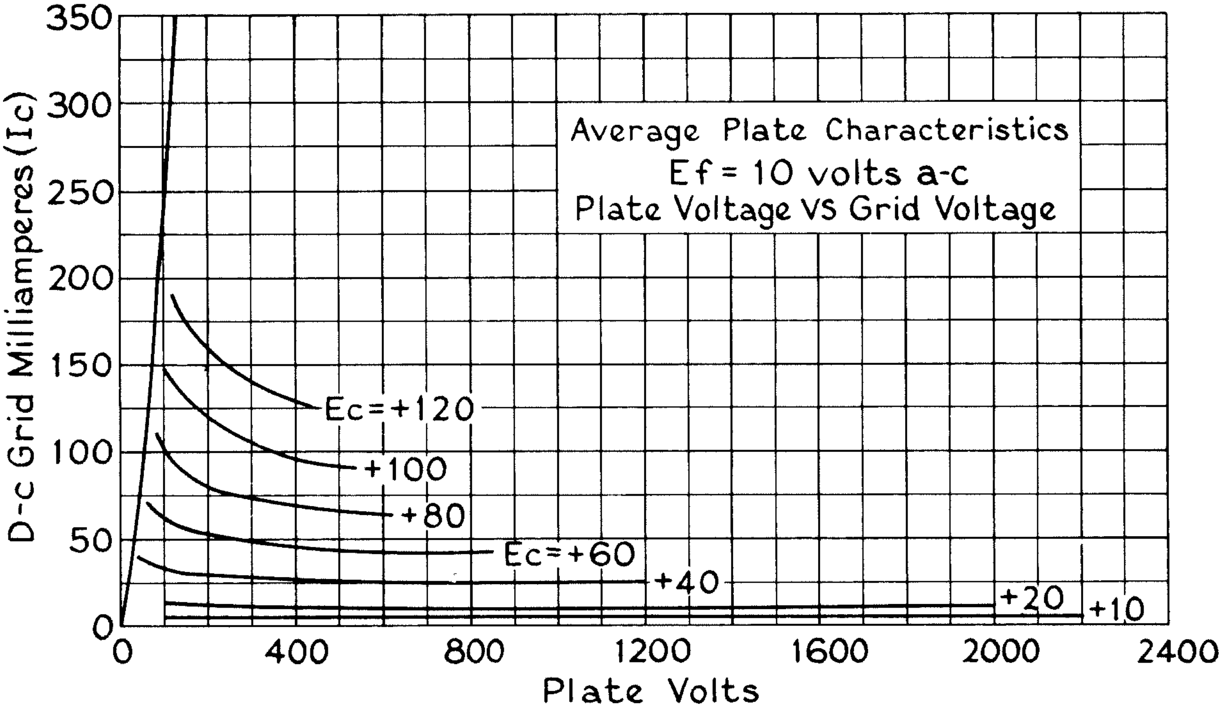
CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
Key-down conditions per tube without modulation†

	Typical Operation			Maximum Rating	
D-c Plate Voltage	750	1000	1250	1250	Volts
D-c Grid Voltage	-80	-85	-90	-400	Volts
D-c Plate Current	150	150	150	175	Milliamperes
D-c Grid Current, approx	30	30	30	70	Milliamperes
Plate Input				220	Watts
Plate Dissipation				100	Watts
Peak R-f Grid Input Voltage, approx	190	195	200		Volts
Driving Power, approx	6	6	6		Watts
Plate Power Output	65	100	130		Watts

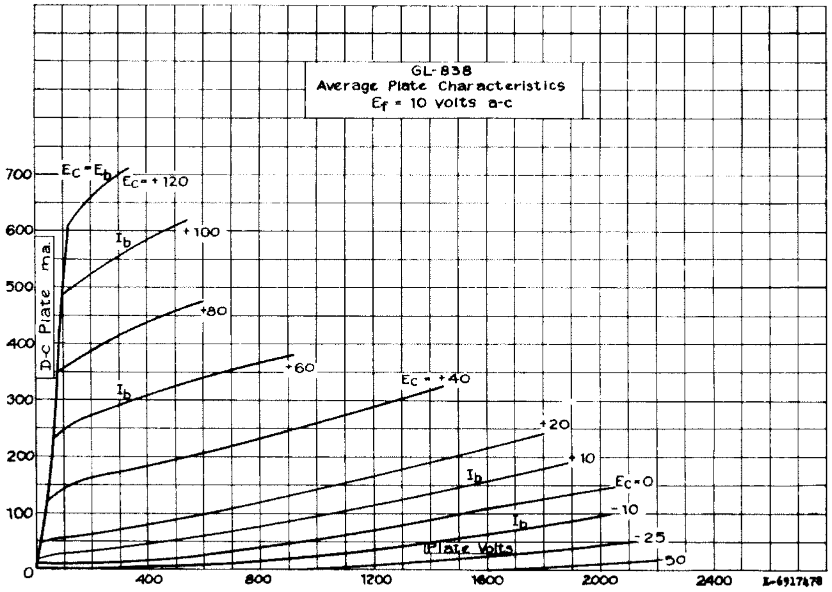
† Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

GL-838 can be operated at maximum ratings in all classes of service at frequencies as high as 30 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown under CHARACTERISTICS). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 120 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

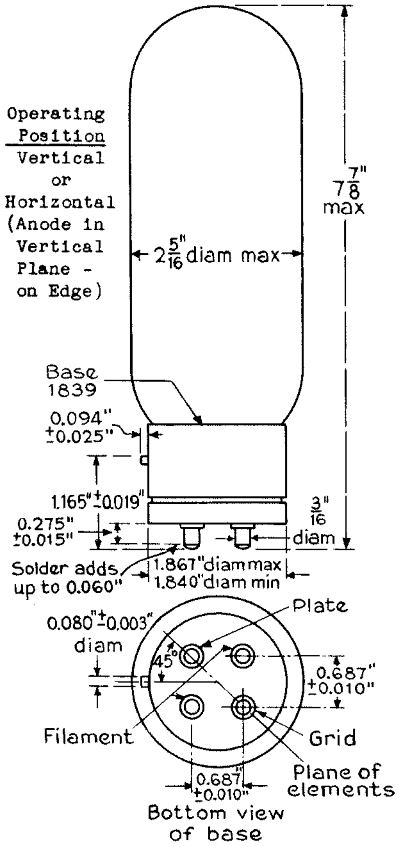
FREQUENCY	30	50	120	Mc
Maximum Permissible Percentage of Maximum Rated Plate Voltage and Plate Input:				
Class B Telephony	100	85	73	Per Cent
Class C (Telephony / (Telegraphy	100	75	50	Per Cent



K-6917436 Average Plate Characteristics 11-7-39



K-6917478 Average Plate Characteristics 4-16-40



Outline Transmitting Tube GL-838
K-4909036

GENERAL ELECTRIC
SCHENECTADY, N.Y.

2-42 (4M)
Filing No. 8850

Supersedes GET-920B

PRINTED IN U.S.A.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-842--Description and Rating

The GL-842 is a three-electrode, low-millimicron tube, containing a filament of the thoriated-tungsten type. Because this tube is primarily used as a Class A power amplifier, it is useful as a modulator in low-power transmitting equipment.

TECHNICAL INFORMATION

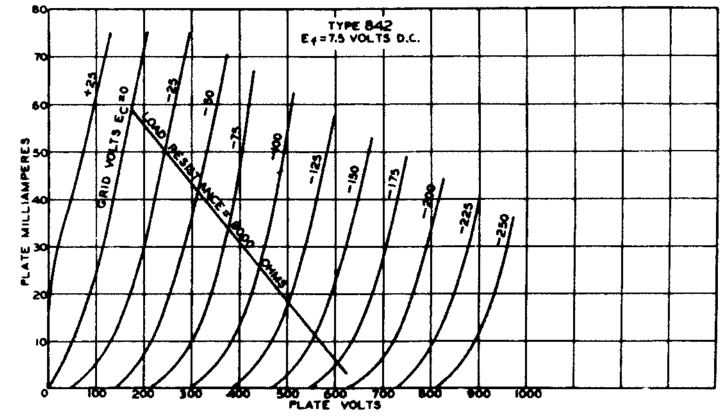
GENERAL DESIGN

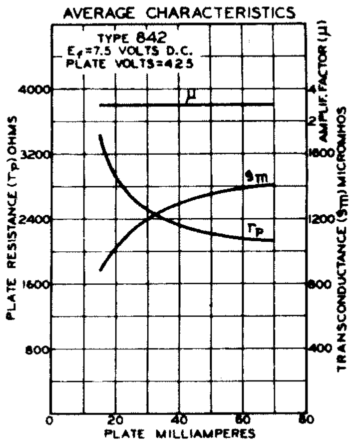
Filament Voltage	7.5 Volts
Filament Current	1.25 Amperes
Direct Interelectrode Capacitances:	
Grid-plate	7 uuf
Grid-filament	4 uuf
Plate-filament	3 uuf
Base	Medium 4-pin Bayonet
Net Weight, Approx	3 Ounces
Shipping Weight, Approx	3 Pounds
Installation and Operation	GEH-980

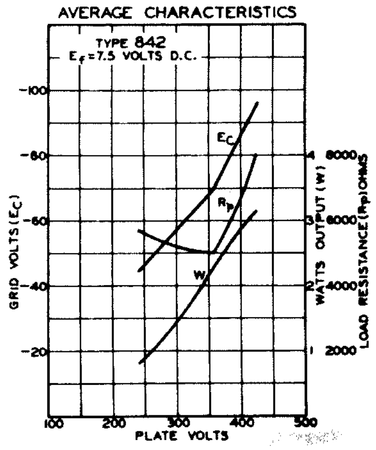
MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS
As A-F Power Amplifier and Modulator - Class A

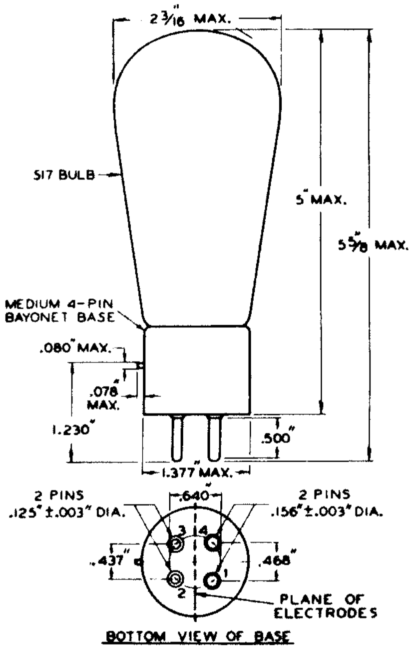
	Typical Operating Conditions		Maximum Ratings	
D-c Plate Voltage	350	425	425	Volts
Plate Dissipation			12	Watts
D-c Grid Voltage*	-72	-100		Volts
Peak A-F Grid Voltage	67	95		Volts
D-c Plate Current	34	28		Milliamperes
Plate Resistance	2400	2500		Ohms
Amplification Factor	3	3		
Transconductance	1250	1200		Micromhos
Load Resistance	5000	8000		Ohms
Cathode-Bias Resistor	2120	3570		Ohms
Undistorted Power Output	2.1	3.0		Watts

* Grid voltages are given with respect to the mid-point of filament operated on alternating current. If direct current is used, each stated value of grid voltage should be decreased by 5 volts and the circuit returns made to the negative end of the filament.

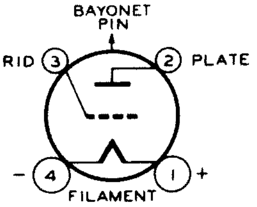








Tube Symbol and Top View of Socket Connections



3-44 (7M)
Filing No 8850

GENERAL ELECTRIC

Transmitting Tube GL-843 - - Description and Rating

The 843 is a three-electrode power tube of the heater-cathode type. It is designed for use as an oscillator, a-f power amplifier, or r-f power amplifier.

CHARACTERISTICS

Heater Voltage (a-c or d-c)	2.5	Volts
Heater Current	2.5	Amperes
Amplification Factor	7.7	
Grid-plate Capacitance	6	μμf
Grid-cathode Capacitance	5	μμf
Plate-cathode Capacitance	5	μμf
Base	Medium 5-pin	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

AS A-F POWER AMPLIFIER - CLASS A

D-c Plate Voltage		425 max	Volts
Plate Dissipation		12 max	Watts
Typical Operation:			
D-c Plate Voltage	350	425	Volts
Grid Voltage (approx)	-25	-35	Volts
Peak Grid Swing (approx)	25	35	Volts
D-c Plate Current	25	25	Milliamperes
Amplification Factor	7.7	7.7	
Plate Resistance	4700	4800	Ohms
Mutual Conductance	1700	1600	Micromhos
Load Resistance	9500	12000	Ohms
Undistorted Power Output	0.95	1.6	Watts

AS R-F POWER AMPLIFIER - CLASS B TELEPHONY
Carrier conditions; for use with a modulation factor up to 1.0

D-c Plate Voltage		450 max	Volts
D-c Plate Current		30 max	Milliamperes
Plate Dissipation		15 max	Watts
R-f Grid Current		4 max	Amperes
Typical Operation:			
D-c Plate Voltage	350	450	Volts
Grid Voltage (approx)	-40	-50	Volts
D-c Plate Current	25	25	Milliamperes
Peak Power Output (approx)	8	12	Watts
Carrier Power Output (approx)	2	3	Watts

AS PLATE-MODULATED R-F POWER AMPLIFIER - CLASS C TELEPHONY
Carrier conditions; for use with a modulation factor up to 1.0

D-c Plate Voltage		350 max	Volts
D-c Plate Current		40 max	Milliamperes
Plate Dissipation		10 max	Watts
R-f Grid Current		4 max	Amperes
D-c Grid Current		7.5 max	Milliamperes
Typical Operation:			
D-c Plate Voltage	250	350	Volts
Grid Voltage (approx)	-100	-140	Volts
D-c Plate Current	30	30	Milliamperes
D-c Grid Current*	7	7	Milliamperes
Driving Power*	1.3	1.6	Watts
Power Output (approx)	3	5	Watts

AS R-F POWER AMPLIFIER AND OSCILLATOR - CLASS C TELEGRAPHY
Key-down conditions

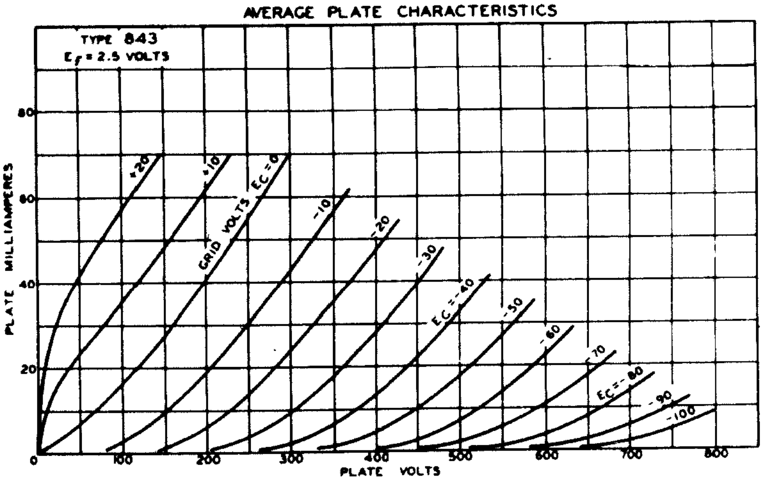
D-c Plate Voltage	450 max	Volts
D-c Plate Current	40 max	Milliamperes
Plate Dissipation	15 max	Watts
R-f Grid Current	5 max	Amperes
D-c Grid Current	7.5 max	Milliamperes

Typical Operation:

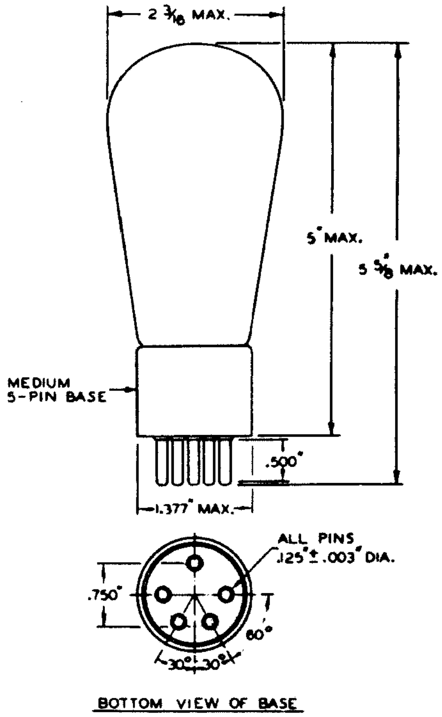
D-c Plate Voltage	350	450	Volts
Grid Voltage (approx)	-100	-149	Volts
D-c Plate Current	30	30	Milliamperes
D-c Grid Current*	5	5	Milliamperes
Driving Power*	0.8	1.0	Watt
Power Output (approx)	5	7.5	Watts

* Subject to wide variations depending on the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits need less grid current and driving power, but plate-circuit efficiency is sacrificed. The driving stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.

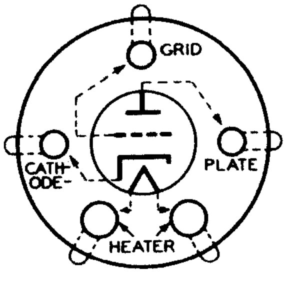
AVERAGE PLATE CHARACTERISTICS



OUTLINE DRAWING



Tube Symbol and Top View of Socket Connections



GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

GENERAL ELECTRIC

Transmitting Tube GL-845 -- Description and Rating

The GL-845 is a three-electrode vacuum tube especially adapted to use as a Class A power amplifier or modulator.

Technical Information

These data are for reference only. For design information see the specifications.

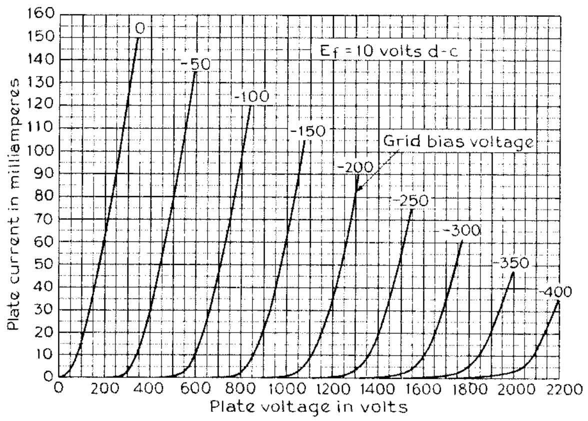
GENERAL CHARACTERISTICS:

Filament Voltage, volts	10
Filament Current, amperes	3.25
Amplification Factor	5.3
Grid-plate Transconductance, mmhos Ib = 65	2800
Direct Interelectrode Capacitances, μμf	
Grid-plate	13.5
Input	6.0
Output	6.5
Base or Terminal Description	Jumbo, 4-Large Pin
Net Weight, oz approx	8
Shipping Weight, lb approx	7
Installation and Operation Instructions	GEH-930

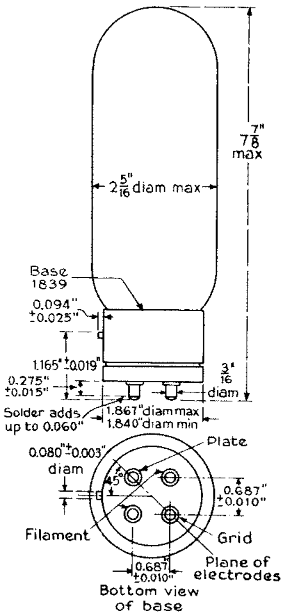
MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS A A-F AMPLIFIER AND MODULATOR:

	Typical Operation			Max Ratings
D-c Plate Voltage, v	750	1000	1250	1250
Plate Dissipation, w	---	---	---	100
D-c Grid Voltage, v	-98	-145	-195	---
Peak Grid Swing, approx v	93	140	190	---
D-c Plate Current, ma	95	90	80	---
Plate Resistance, ohms	1700	1700	1700	---
Load Resistance, ohms	3400	6000	11000	---
Plate Power Output (5% Second Harmonic), w	15	24	30	---



Average Plate Characteristics for Transmitting Tube GL-845
K-6917425 10-3-39



Outline Transmitting Tube GL-845
K-4909036 4-4-40

CLASS AB_1 A-F POWER AMPLIFIER AND MODULATOR

	Typical Operation		Max Ratings	
D-c Plate Voltage	1000	1250	1250	Volts
Plate Dissipation			100	Watts
D-c Grid Voltage	-175	-225	-400	Volts
D-c Plate Current			120	Ma
Peak A-F Grid-to-Grid Voltage	340	440		Volts
Zero Signal D-c Plate Current	40	40		Ma
Max Signal D-c Plate Current	230	240		Ma
Load Resistance	1150	1650		Ohms
Effective Load Resistance, plate-to-plate	4600	6600		Ohms
Plate Power Output, approx	75	115		Watts

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.
9-42 (5M)
Filing No. 8850
PRINTED IN U.S.A.

GENERAL ELECTRIC

Transmitting Tube GL-846 - - Description and Rating

The GL-846 is a three-electrode, water-cooled vacuum tube designed for use as a radio-frequency amplifier and oscillator, particularly at the higher radio frequencies.

Technical Information

(These data for reference only. For equipment design see specifications.)

GENERAL CHARACTERISTICS

ELECTRICAL

Filament - Pure Tungsten	
Voltage	11 Volts
Current	51 Amperes
Average Characteristics, Eb = 6500, Ib = 0.25 Amp, Ef = 11	
Grid Voltage	0 Volts
Amplification Factor	40
Grid-plate Transconductance	2160 Micromhos
Direct Interelectrode Capacitances	
Grid-plate	9 μμf
Input	6.5 μμf
Output	1.5 μμf
Frequency for Maximum Ratings	50 Megacycles

MECHANICAL

Type of Cooling	Water
Water Flow 2-4 Gallons Per Minute	
Maximum Outlet Temperature 70 C	
Mounting Position	Vertical, Anode Down
Gasket Cat. No. 5182028P3	
Maximum Over-all Dimensions (See Outline)	
Length	9 1/2 Inches
Diameter	2 3/4 Inches
Net Weight, Approximately	1 1/8 Pounds
Installation and Operation Instruction	GEH-1152

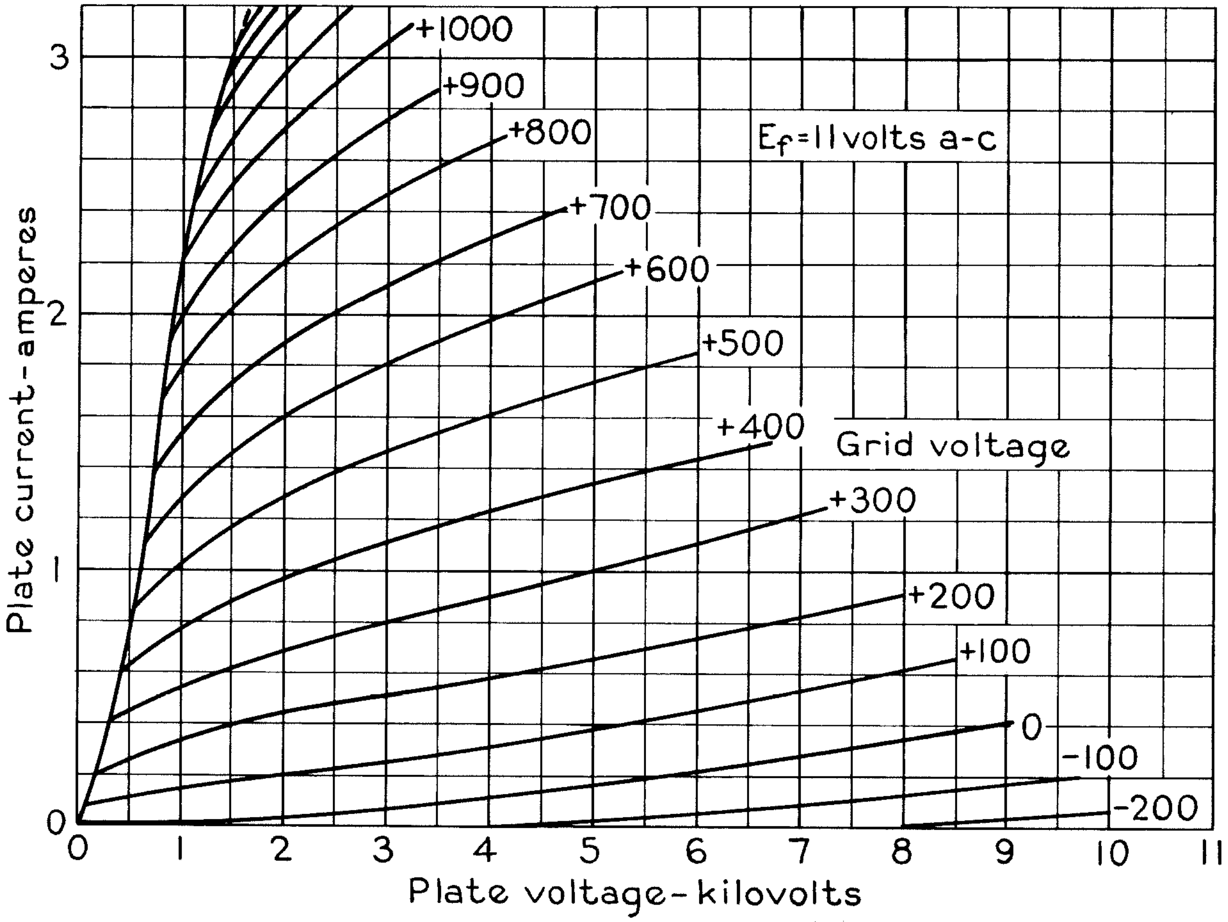
CLASS B RADIO FREQUENCY POWER AMPLIFIER
(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation	Maximum Ratings
D-c Plate Voltage	7000	7500 Volts
D-c Grid Voltage (Grid No. 1)	-100	Volts
D-c Plate Current	0.45	0.5 Volts
Plate Input		3.75 Kilowatts
Plate Dissipation		2.5 Kilowatts
Peak R-F Grid Input Voltage	640	Volts
Driving Power X, Approximately	175	Watts
Plate Power Output, Approximately	1	Kilowatt

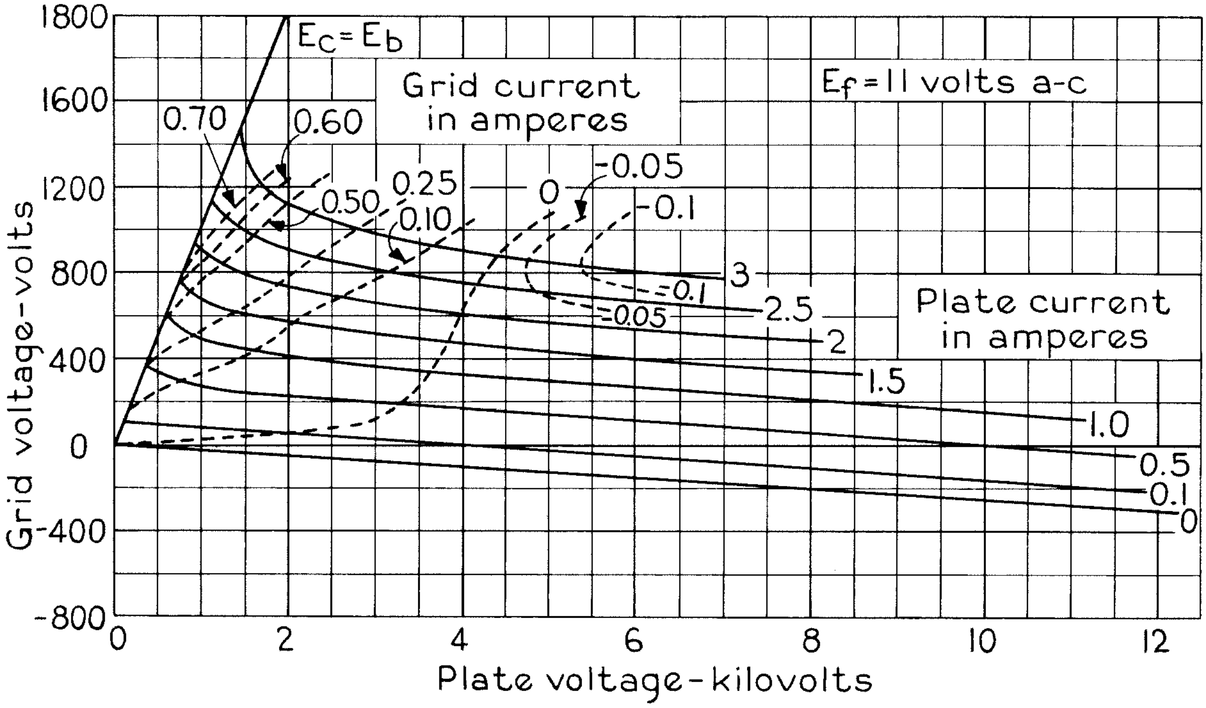
X at Crest of Audio-Frequency Cycle

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR, PLATE MODULATED
(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation			Maximum Ratings
D-c Plate Voltage	4000	5000	6000	6000 Volts
D-c Grid Voltage (Grid No. 1)	-850	-900	-950	-1000 Volts



K-7050551 Average Plate Characteristic for Transmitting Tube GL-846 6-21-34



K-7050624 Characteristics for Transmitting Tube GL-846 6-19-39

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR, PLATE MODULATED
(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation			Maximum Ratings
D-c Plate Current	0.3	0.4	0.5	0.5 Ampere
D-c Grid Current, Approximately	0.08	0.1	0.125	0.15 Ampere
Plate Input				3 Kilowatts
Plate Dissipation				1.66 Kilowatts
Peak R-F Grid Input Voltage	1600	1700	1950	Volts
Driving Power	125	175	200	Watts
Plate Power Output	0.9	1.5	2.25	Kilowatts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR
(Key down conditions per tube without modulation)*

	Typical Operation			Maximum Ratings
D-c Plate Voltage	5000	6000	7000	7500 Volts
D-c Grid Voltage (Grid No. 1)	-800	-850	-900	-1000 Volts
D-c Plate Current	0.6	0.75	0.9	1.0 Ampere
D-c Grid Current, Approximately	0.11	0.125	0.14	0.15 Ampere
Plate Input				7.5 Kilowatts
Plate Dissipation				2.5 Kilowatts
Peak R-F Grid Input Voltage, Approximately	1850	2040	2300	Volts
Driving Power, Approximately	175	235	300	Watts
Plate Power Output, Approximately	2	3	4.25	Kilowatts

* Modulation, essentially negative, may be used if the positive peak of the Audio-Frequency envelope does not exceed 115 per cent of the carrier conditions.

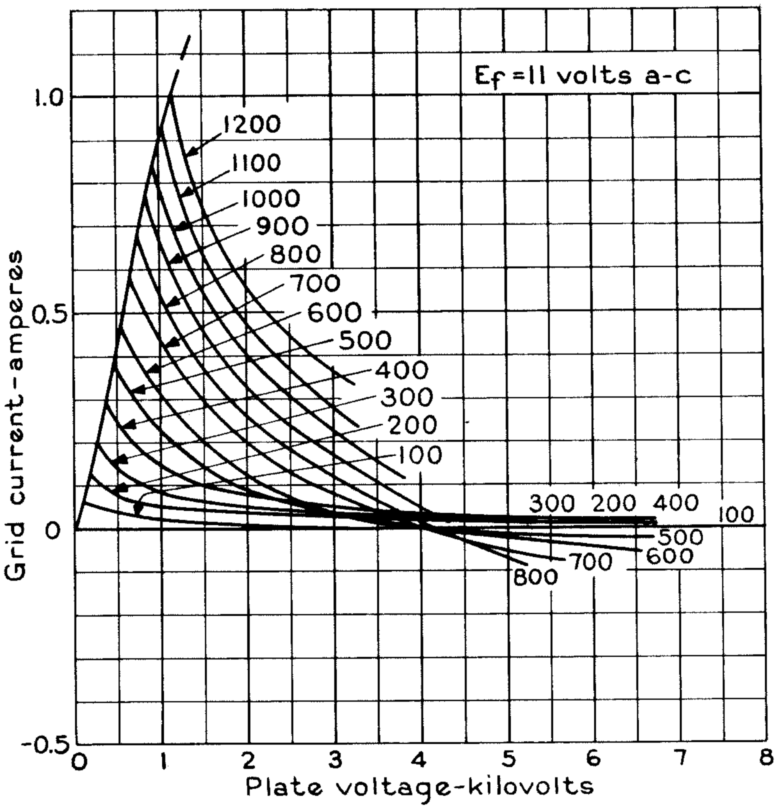
The GL-846 can be operated at frequencies as high as 50 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 150 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

FREQUENCY	50	100	150 Megacycles
PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT			
Class B	100	82	73 Per Cent
Class C Plate Modulated	100	75	60 Per Cent
Class C Unmodulated	100	75	50 Per Cent

APPLICATION NOTES

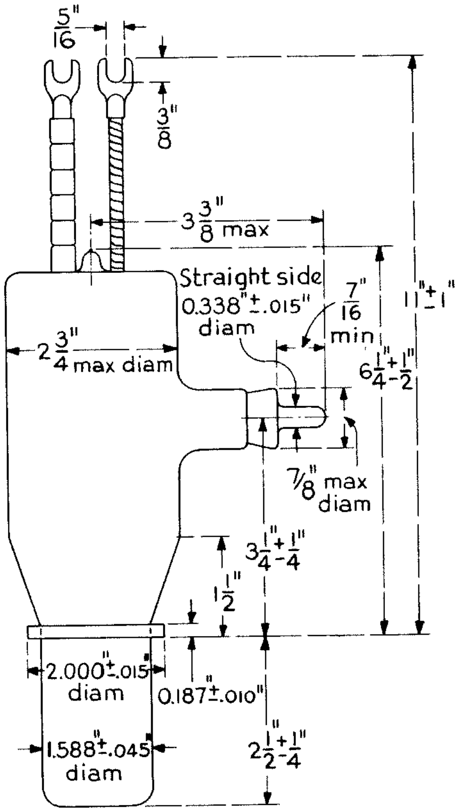
Plate Series Protective Resistors (see paragraph describing plate circuit under Installation in the Instructions.)

Series Resistor, ohms	120	75	100
Maximum Power Output of Rectifier, kilowatts	6.4	16	40



Typical Plate-grid Transfer Characteristic for Transmitting Tube GL-846

K-7050590 6-21-34



Outline Transmitting Tube GL-846

K-4903580 5-15-39

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

7-43 (4M)
Filing No. 8850

Supersedes GET-603A

PRINTED IN U.S.A.

GENERAL ELECTRIC

Transmitting Tube GL-849—Description and Rating

TECHNICAL INFORMATION

The GL-849 is a three-electrode, general-purpose vacuum tube especially suited for use as a Class A audio-frequency power amplifier or modulator.

These data are for reference only. For design information, see the specifications.

CHARACTERISTICS AND RATINGS

Filament Voltage	11	Volts
Filament Current	5	Amperes
Amplification Factor (I_b = 0.1)	19	
Grid-plate Transconductance	6000	Micromhos
Direct Interelectrode Capacitances:		
Grid-plate	33.5	μμf
Input	17	μμf
Output	3	μμf
Base	3503	
Frequency for Maximum Ratings	3	Megacycles
Net Weight (approx)	3	Pounds

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS A A-F AMPLIFIER AND MODULATOR

D-c Plate Voltage	2000	2500	3000	3000 max	Volts
Plate Dissipation				300 max	Watts
D-c Grid Voltage	-74	-104	-132		Volts
Peak Grid Swing (approx)	68	98	126		Volts
D-c Plate Current	0.135	0.110	0.100		Ampere
Plate Resistance	2950	3150	3250		Ohms
Load Resistance	6000	12000	18000		Ohms
Plate Power Output (5% second harmonic)	58	81	100		Watts

CLASS B A-F POWER AMPLIFIER (TWO TUBES)

D-c Plate Voltage	2000	2500	3000	3000 max	Volts
Max Signal Plate Current(per tube)*				0.35 max	Ampere
D-c Max Signal Plate Input (per tube)*				825 max	Watts
Plate Dissipation (per tube)*				300 max	Watts
D-c Grid Voltage	-105	-130	-155		Volts
Peak A-f Grid Input Voltage	450	480	500		Volts
Zero Signal Plate Current	0.014	0.02	0.024		Ampere
Max Signal Plate Current	0.65	0.56	0.52		Watts
Max Signal Plate Input*	1300	1400	1560		Watts
Max Signal Driving Power (approx)	16	14	12		Watts
Effective Load Resistance (plate-to-plate)	6400	10400	12800		Ohms
Max Signal Plate Power Output	900	1000	1100		Watts

CLASS B R-F POWER AMPLIFIER

Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	1500	2000	2500	2500 max	Volts
D-c Grid Voltage	-70	-95	-125		Volts
D-c Plate Current	0.320	0.265	0.216	0.35 max	Ampere
Plate Input				600 max	Watts
Plate Dissipation				400 max	Watts
Peak R-f Grid Input Voltage	280	280	280		Volts
Driving Power (approx)**	18	15	12		Watts
Plate Power Output	150	170	180		Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE-MODULATED
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	1500	2000	2000 max	Volts
D-c Grid Voltage	-250	-300	-500 max	Volts
D-c Plate Current	0.3	0.3	0.35 max	Ampere
D-c Grid Current (approx)	0.035	0.03	0.125 max	Ampere
Plate Input			700 max	Watts
Plate Dissipation			270 max	Watts
Peak R-f Grid Input Voltage (approx)	400	450		Volts
Driving Power (approx)	14	14		Watts
Plate Power Output	300	425		Watts

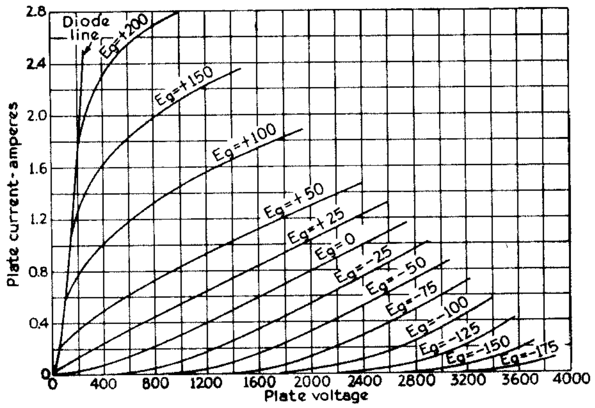
CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
Key-down conditions per tube without modulation #

D-c Plate Voltage	1500	2000	2500	2500 max	Volts
D-c Grid Voltage	-175	-200	-250	-500 max	Volts
D-c Plate Current	0.3	0.3	0.3	0.35 max	Ampere
D-c Grid Current (approx)	0.035	0.025	0.02	0.125 max	Ampere
Plate Input				875 max	Watts
Plate Dissipation				400 max	Watts
Peak R-f Grid Input Voltage (approx)	310	325	360		Volts
Driving Power (approx)	11	9	8		Watts
Plate Power Output	300	425	560		Watts

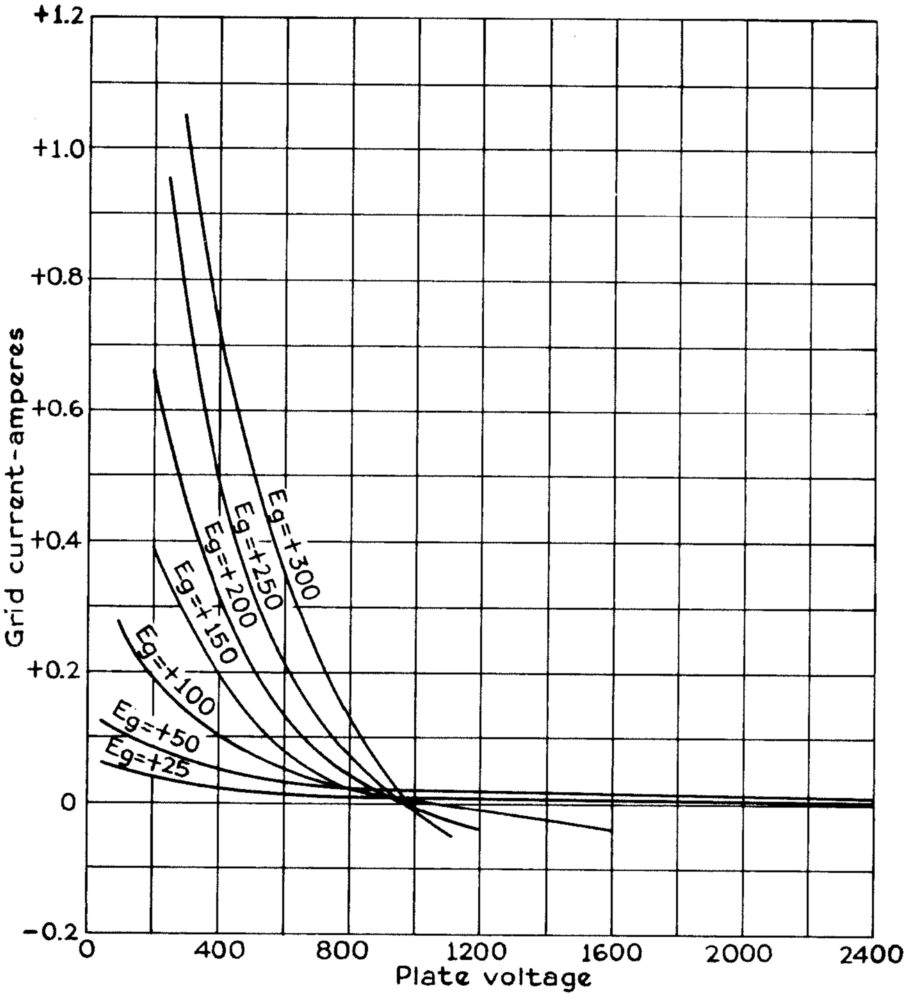
* Averaged over any audio-frequency cycle.
** At crest of audio-frequency cycle.
\# Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

GL-849 can be operated at maximum ratings in all classes of service at frequencies as high as 3 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under TECHNICAL INFORMATION.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 30 mc for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

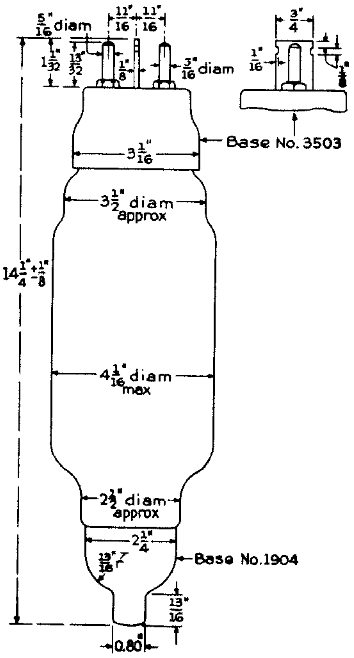
FREQUENCY	3	10	30	Mc
MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT:				
Class B telephony	100	84	69	Per cent
Class C (telephony, plate-modulated (telegraphy	100	75	50	Per cent



Average Plate Characteristics for
Transmitting Tube GL-849
K-7000102 6-3-35



Average Grid-plate Characteristics
for **Transmitting Tube** GL-849
K-7000103 6-3-35



Outline Transmitting Tube GL-849
K-3846004 12-13-39

GENERAL ELECTRIC
SCHENECTADY, N.Y.

10-43 (5M)
Filing No. 8850

PRINTED IN U.S.A.

Superseding GET-489A

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-851---Description and Rating

The GL-851 is a three-electrode, general-purpose electronic tube.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

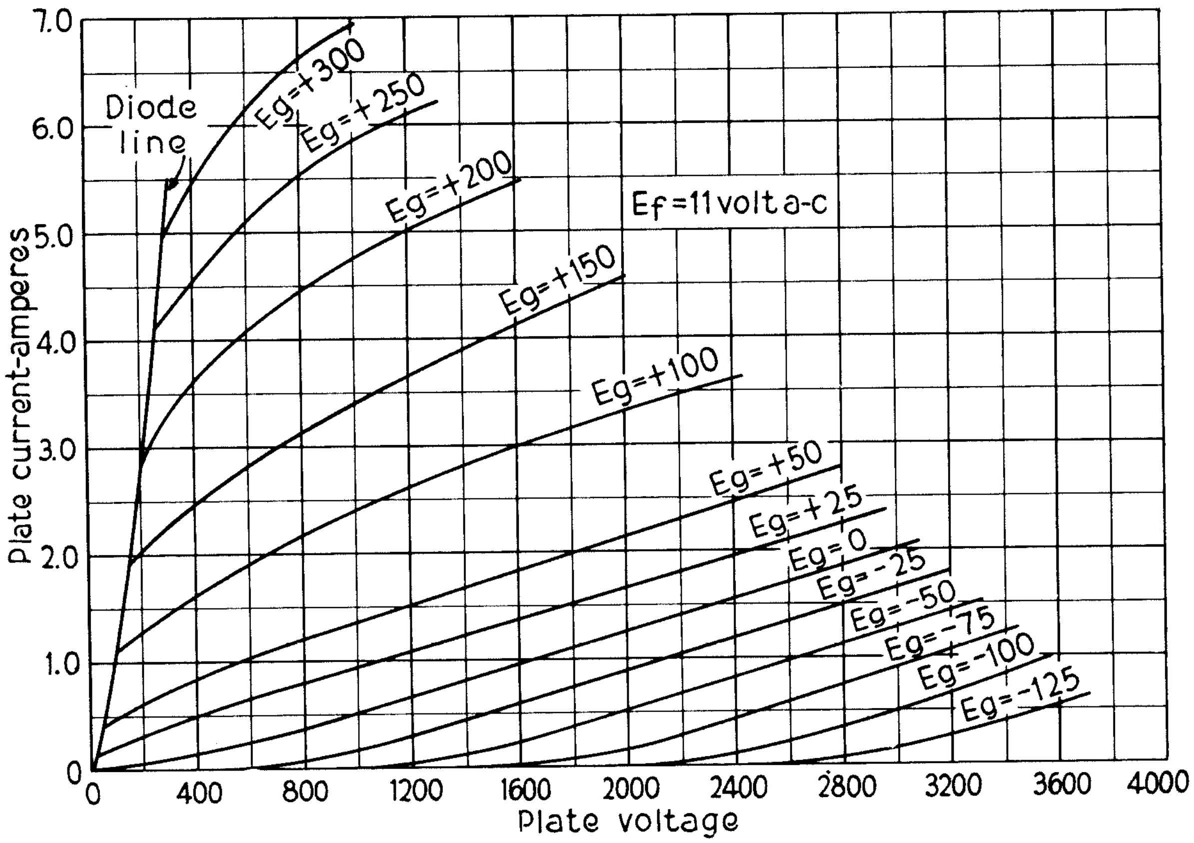
Filament Voltage	11 max	Volts
Filament Current	15.5 max	Amperes
Amplification Factor, I_b = 300 ma	20.5	
Grid-plate Transconductance	15000 max	Micromhos
Direct Interelectrode Capacitances:		
Grid Plate	47 max	uuf
Input	25.5 max	uuf
Output	4.5 max	uuf
Base	3117	
Frequency for Max Ratings	3 max	Megacycles
New Weight, approx	3	Pounds
Shipping Weight, approx	9	Pounds
Installation and Operation	GEH-980	

MAXIMUM RATING AND TYPICAL OPERATING CONDITIONS

	Typical Operation			Maximum Ratings	
CLASS A A-F AMPLIFIER AND MODULATOR					
D-c Plate Voltage	1500	2000	2500	2500	Volts
Plate Dissipation				600	Watts
D-c Grid Voltage	-49	-65	-92		Volts
Peak Grid Swing, approx	44	60	87		Volts
D-c Plate Current	0.175	0.270	0.240		Ampere
Plate Resistance	1800	1500	1600		Ohms
Load Resistance	3700	3100	5000		Ohms
Plate Power Output, 5 per cent second harmonic	46	100	160		Watts
CLASS B A-F POWER AMPLIFIER (TWO TUBES)					
D-c Plate Voltage	2000	2500	3000	3000	Volts
Max Signal Plate Current, per tube*				1	Ampere
D-c Max Signal Plate Input, per tube*				2250	Watts
Plate Dissipation, per tube*				750	Watts
D-c Grid Voltage	-85	-111	-135		Volts
Peak A-f Grid Input Voltage	250	245	245		Volts
Zero Signal Plate Current	0.12	0.12	0.11		Ampere
Max Signal Plate Current	1.7	1.4	1.2		Amperes
Max Signal Plate Input*	3400	3500	3600		Watts
Max Signal Driving Power, approx	20	12	6		Watts
Effective Load Resistance, plate-to-plate	2600	4000	5600		Ohms
Max Signal Plate Power Output	2200	2300	2400		Watts

	Typical Operation			Maximum Ratings	
CLASS B R-F POWER AMPLIFIER					
Carrier conditions per tube for use with a max modulation factor of 1.0					
D-c Plate Voltage	1500	2000	2500	2500	Volts
D-c Grid Voltage	-60	-85	-110		Volts
D-c Plate Current	0.62	0.475	0.39	0.750	Ampere
Plate Input				1100	Watts
Plate Dissipation				750	Watts
Peak R-f Grid Input Voltage	300	280	270		Volts
Driving Power, approx†	40	25	20		Watts
Plate Power Output	275	300	325		Watts

	Typical Operation		Maximum Ratings	
CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED				
Carrier conditions per tube for use with a max modulation factor of 1.0				
D-c Plate Voltage	1500	2000	2000	Volts
D-c Grid Voltage	-250	-300	-500	Volts
D-c Plate Current	0.9	0.85	1	Ampere
D-c Grid Current, approx	0.15	0.125	0.200	Ampere
Plate Input			1800	Watts
Plate Dissipation			500	Watts
Peak R-f Grid Input Voltage, approx	475	525		Volts
Driving Power, approx	75	65		Volts
Plate Power Output	900	1250		Watts



Average Grid-plate Characteristics for Transmitting Tube GL-851

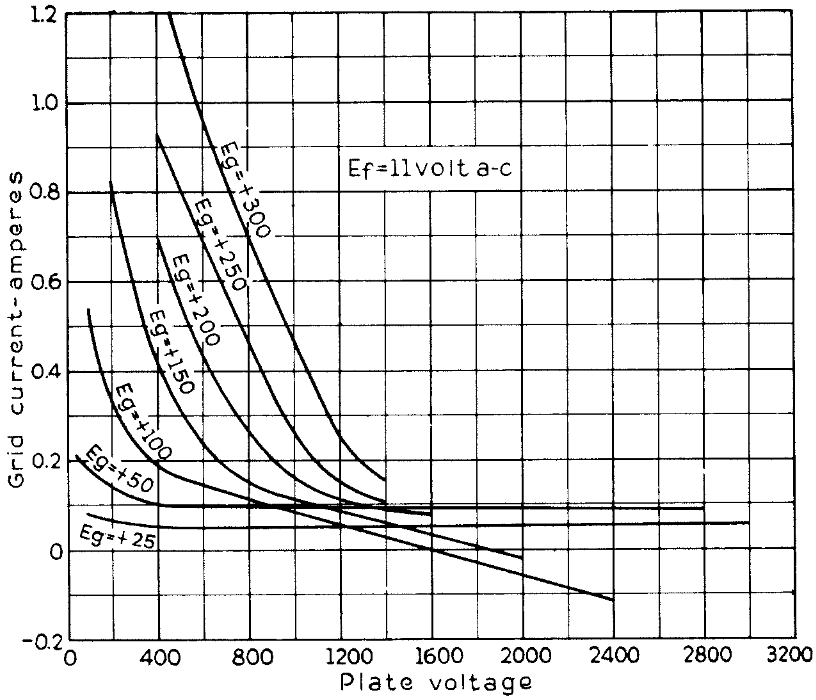
K-6966441 2-10-41

	Typical Operation			Maximum Ratings	
CLASS C R-F POWER AMPLIFIER AND OSCILLATOR					
Key down conditions per tube without modulation‡					
D-c Plate Voltage	1500	2000	2500	2500	Volts
D-c Grid Voltage	-150	-200	-250	-500	Volts
D-c Plate Current	0.9	0.9	0.9	1	Ampere
D-c Grid Current, approx	0.15	0.12	0.1	0.200	Ampere
Plate Input				2500	Watts
Plate Dissipation				750	Watts
Peak R-f Grid Input Voltage, approx	375	425	450		Volts
Driving Power, approx	55	50	45		Watts
Plate Power Output	900	1250	1700		Watts

* Averaged over any audio-frequency cycle.
† At crest of audio-frequency cycle.
‡ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

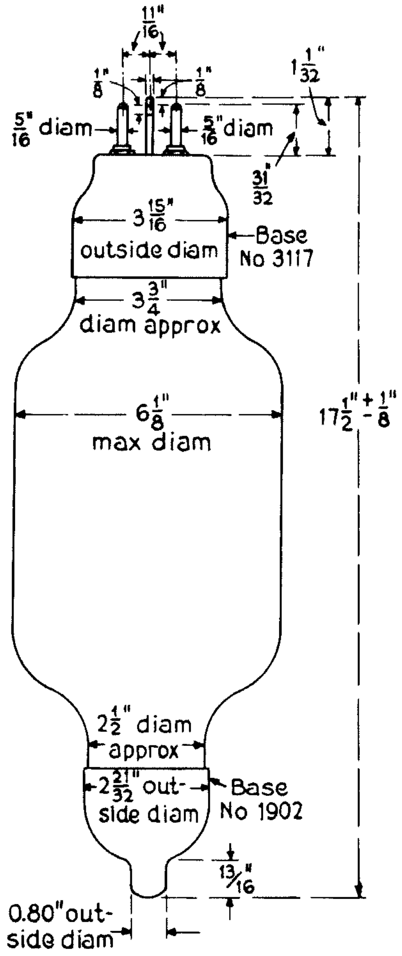
Tube Mounting Position

Vertical: Filament base (large) up
Horizontal: Filament in vertical plane (on edge)



Average Plate Characteristics for Transmitting Tube GL-851

K-6966442 2-10-41



Outline Transmitting Tube GL-851

K-2636625 3-27-34

GL-851 can be operated at maximum ratings in all classes of service at frequencies as high as 3 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under TECHNICAL INFORMATION.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 15 mc for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

		3	7	15	
FREQUENCY		3	7	15	Mc
MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT:					
Class B	Telephony	100	88	76	Per Cent
Class C	(Telephony, plate-modulated (Telegraphy	100	75	50	Per Cent

G E N E R A L E L E C T R I C C O M P A N Y , S C H E N E C T A D Y , N . Y .

3-44 (7M)
Filing No. 8850

Supersedes
GET-504D

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-858--Description and Rating

The GL-858 is a three-electrode, water-cooled high-vacuum electronic tube designed for use as a radio-frequency power amplifier, oscillator, or Class B modulator.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage		22	Volts
Filament Current		52	Amperes
Amplification Factor	E_b = 18 kv, I_b = 75 ma	42	
Grid-plate Transconductance	E_c = -155, E_f = 22	4800	Micromhos
Direct Interelectrode Capacitances:			
Grid-plate		18	μμf
Input		16	μμf
Output		2	μμf
Frequency for Maximum Ratings		1.6	Megacycles

Mechanical

Gasket, Cat. No. 5182028P2		
Type of Cooling		Water
Water Flow, gallons per minute	8-15	
Net Weight, approx	8	Pounds
Shipping Weight, approx	23	Pounds
Installation and Operation	GEH-1152	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B A-F POWER AMPLIFIER (TWO TUBES)

D-C Plate Voltage	12000	20000 max	Volts
Max Signal Plate Current, per tube*		2.0 max	Amperes
D-C Max Signal Plate Input, per tube*		40 max	Watts
Plate Dissipation, per tube*		20 max	Kilowatts
D-C Grid Voltage	-140		Volts
Peak A-F Grid Input Voltage	2600		Volts
Zero Signal Plate Current	0.5		Ampere
Max Signal Plate Current	3.6		Amperes
Max Signal Plate Input*	43		Watts
Max Signal Driving Power, approx	115		Watts
Effective Load Resistance, plate-to-plate	7200		Ohms
Max Signal Plate Power Output	26.5		Kilowatts

CLASS B R-F POWER AMPLIFIER

Carrier conditions per tube for use with a max modulation factor of 1.0

D-C Plate Voltage	10000	14000	18000	20000 max	Volts
D-C Grid Voltage	-100	-200	-300		Volts
D-C Plate Current	0.5	0.7	0.9	1.0 max	Ampere
Plate Input				20 max	Kilowatts
Plate Dissipation				15 max	Kilowatts
Peak R-F Grid Input Voltage	400	575	725		Volts
Driving Power, approx†	25	70	85		Kilowatts
Plate Power Output	1.5	3.3	5.6		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE-MODULATED
Carrier Conditions per tube for use with a max modulation factor of 1.0

D-C Plate Voltage	8000	10000	12000	12000 max	Volts
D-C Grid Voltage	-900	-950	-1000	-3000 max	Volts
D-C Plate Current	0.9	0.9	0.95	1.0 max	Ampere
D-C Grid Current, approx	0.10	0.09	0.08	0.25 max	Ampere
Plate Input				12 max	Kilowatts
Plate Dissipation				10 max	Kilowatts
Peak R-F Grid Input Voltage, approx	1875	1950	1950		Volts
Driving Power, approx	180	200	150		Watts
Plate Power Output	5	6	8		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
Key-down conditions per tube without modulation‡

D-C Plate Voltage	10000	15000	18000	20000 max	Volts
D-C Grid Voltage	-1000	-1100	-1200	-3000 max	Volts
D-C Plate Current	1.4	1.8	1.8	2.0 max	Amperes
D-C Grid Current, approx	0.13	0.1	0.1	0.25 max	Ampere
Plate Input				40 max	Kilowatts
Plate Dissipation				20 max	Kilowatts
Peak R-F Grid Input Voltage, approx	2200	2500	2600		Volts
Driving Power, approx	275	250	250		Watts
Plate Power Output	9	18	22.4		Kilowatts

* Averaged over any audio-frequency cycle.
† At crest of audio-frequency cycle.
‡ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

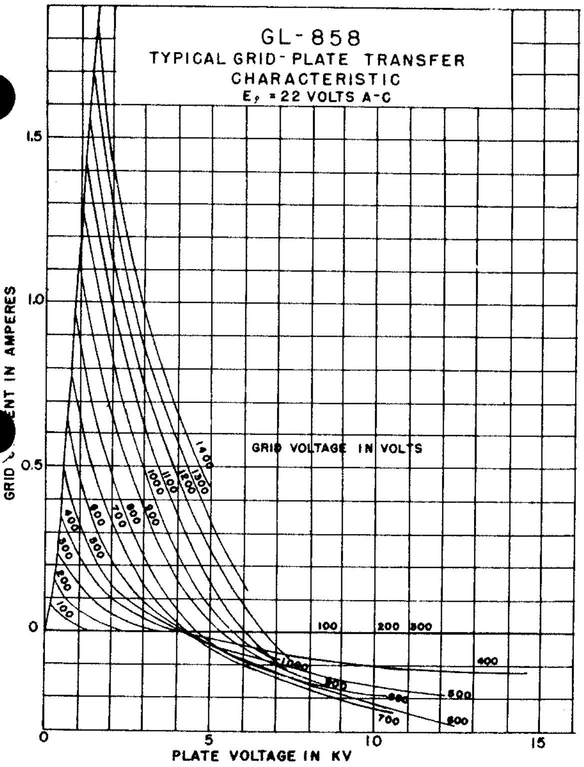
GL-858 can be operated at maximum ratings in all classes of service at frequencies as high as 1.5 megacycle. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown under CHARACTERISTICS AND RATINGS). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 40 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

FREQUENCY	1.5	20	40	Mc
Maximum Permissible Percentage of Maximum rated Plate Voltage and Plate Input:				
Class B Telephony	100	82	57	Per Cent
Class C (Telephony, plate-modulated / (Telegraphy	100	75	50	Per Cent

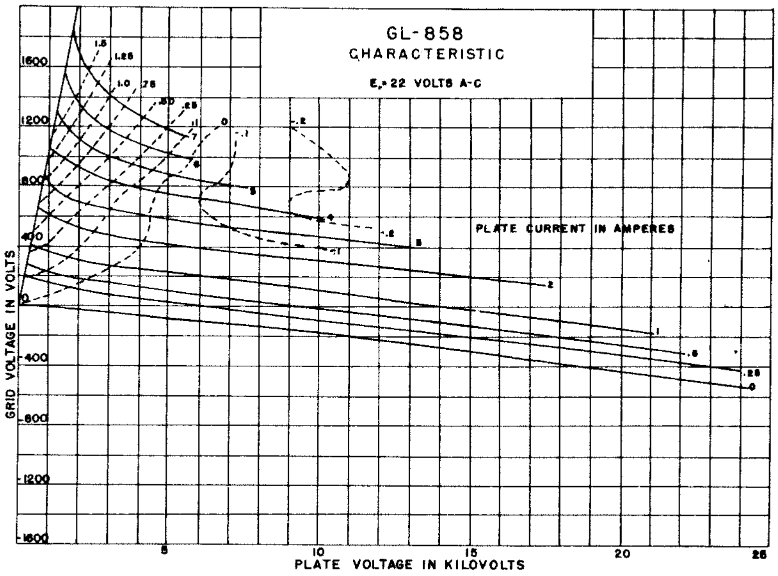
APPLICATION NOTES

Plate Series Protective Resistors (see paragraph describing plate circuit under Installation in the Instructions).

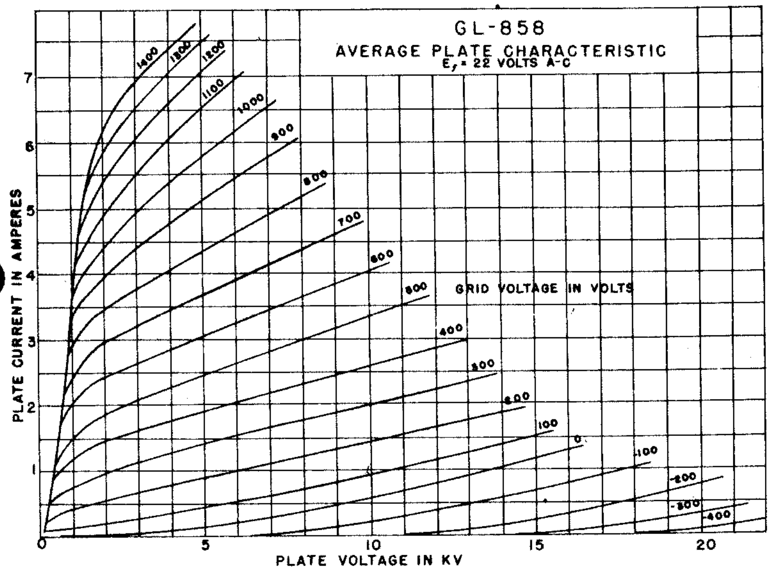
Series Resistor, ohms	25	50	200	250	275	300
Maximum Power Output of Rectifier, kilowatts	16	40	100	250	640	1600



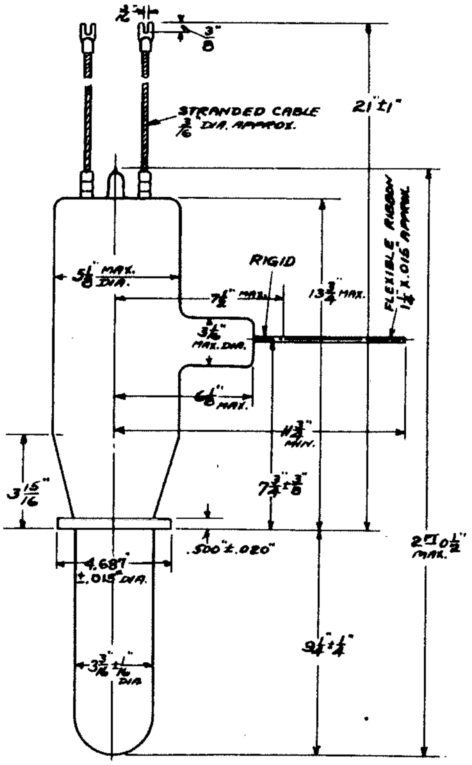
K-8074649 3-16-44



K-8074648 3-17-44



K-8074650 3-17-44



Outline Transmitting Tube GL-858
K-5182096 5-12-39

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

12-44 (7M)
Filing No. 8850

Supersedes ET-T25

PRINTED IN U.S.A.

ELECTRONICS DEPARTMENT
GENERAL ELECTRIC

Transmitting Tube GL-860 - - Description and Rating

The 860 is a four-electrode screen-grid tube designed for use as a Class B and C amplifier in high-frequency circuits.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Filament Voltage, volts	10
Filament Current, amperes	3.25
Amplification Factor, approx	200
Grid-plate Transconductance, mmhos	
I_b = 50 ma	1100
Direct Interelectrode Capacitances, mu mu f	
Grid-plate*	0.08
Input	7.75
Output	7.5
Base or Terminal Description	Medium 4-pin Bayonet
Net Weight, ounces approx	8
Shipping Weight, pounds approx	3

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

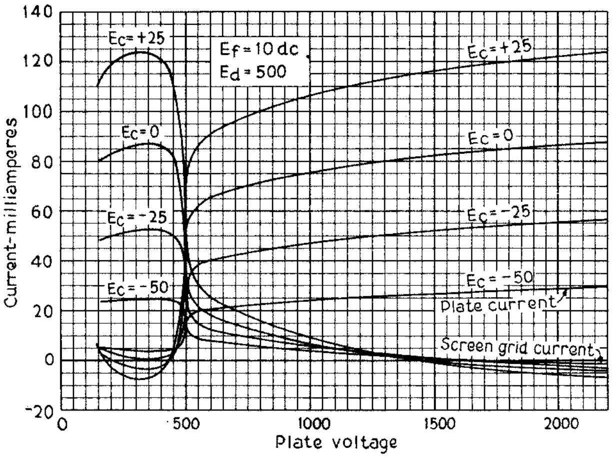
CLASS B RADIO-FREQUENCY POWER AMPLIFIER
(Carrier conditions per tube for use with a maximum modulation factor of 1.0)

	Typical Operation		Max Ratings	
D-c Plate Voltage	2000	3000	3000	volts
D-c Grid Voltage	-50	-50		volts
D-c Screen Voltage†	300	300	500	volts
D-c Plate Current	0.060	0.043	0.085	amp
Plate Input			150	watts
Screen Grid Input			10	watts
Plate Dissipation			100	watts
Plate Power Output	30	40		watts

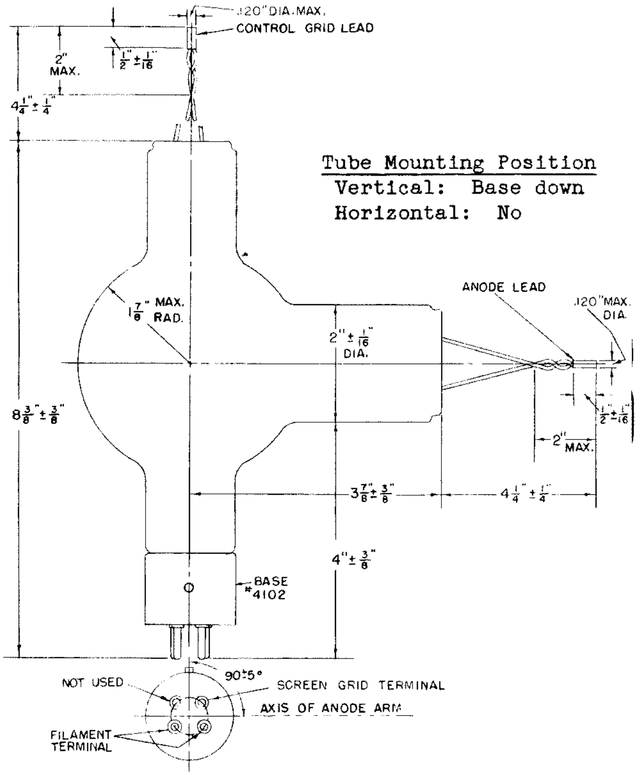
CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR, PLATE MODULATED
(Carrier conditions per tube for use with a maximum modulation factor of 1.0)

D-c Plate Voltage	1500	1800	2000	2000	volts
D-c Grid Voltage	-225	-225	-200	-800	volts
D-c Screen Voltage	300	300	220	500	volts
D-c Plate Current	0.070	0.067	0.085	0.085	amp
D-c Grid Current, approx	0.030	0.030	0.038	0.040	amp
Plate Input				170	watts
Screen Grid Input				6.7	watts
Plate Dissipation				67	watts
Driving Power, approx	15	15	17		watts
Plate Power Output	45	60	105		watts

* With external shielding
† Use of series resistor not recommended



Average Static Characteristics
Transmitting Tube GL-860
H-5178595 4-2-36



Tube Mounting Position
Vertical: Base down
Horizontal: No

Outline Transmitting Tube GL-860
K-5344872 4-5-44

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR

(Key-down conditions per tube without modulation)‡

	Typical Operation				Max Ratings	
D-c Plate Voltage	1500	2000	2500	3000	3000	volts
D-c Grid Voltage	-150	-150	-150	-150	-800	volts
D-c Screen Voltage†	300	300	300	300	500	volts
D-c Plate Current	0.090	0.090	0.090	0.085	0.150	amp
D-c Grid Current, approx	0.015	0.015	0.015	0.015	0.040	amp
Plate Input	135	180	225	255	300	watts
Plate Dissipation	75	80	90	90	100	watts
Screen Grid Input					10	watts
Driving Power, approx	7	7	7	7		watts
Plate Power Output	60	100	135	165		watts

The normal value of grid leak when the tube is used as an oscillator or r-f power amplifier (Class C) is in the neighborhood of 10,000 ohms, although this may be replaced by a fixed bias. If self-bias is used the cathode resistor should be approximately 2000 ohms.

The maximum ratings apply only at frequencies below 30 megacycles. For operation at higher frequencies adequate ventilation and normal ambient temperatures must be maintained, and the plate voltage must be reduced as indicated.

Frequency Megacycles	30	60	120
Percentage of Maximum Rated Plate Voltage and Plate Input			
Class B	100	85	70
Class C	100	75	50

The resonant frequency of the grid-plate circuit is approximately 195 megacycles.

†Use of series resistor not recommended
‡Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

3-44 (8M)
Filing No. 8850

Supersedes GET-500D
PRINTED IN U.S.A.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-861--Description and Rating

The 861 is a four-electrode screen-grid tube designed for use as a Class B and C amplifier in high-frequency circuits.

Technical Information

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

ELECTRICAL

Number of Electrodes	4
Filament Voltage	11 Volts
Filament Current	10 Amperes
Amplification Factor	300
Grid-plate Transconductance, I_b = 130 ma	2400 Micromhos
Direct Interelectrode Capacitance	
Grid-plate, with external shielding	0.10 uuf
Input	14.5 uuf
Output	10.5 uuf

MECHANICAL

Base	3503, 3909
Cap	3910
Net Weight, approx	2 1/2 Pounds
Shipping Weight, approx	9 Pounds
Installation and Operation	GEH-980

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B R-F POWER AMPLIFIER
(Carrier conditions per tube for use with a maximum modulation factor of 1.0)

	Typical Operation			Maximum Ratings*	
Filament Voltage				11	Volts
D-c Plate Voltage	2500	3000	3500	3500	Volts
D-c Grid Voltage	-60	-60	-60		Volts
D-c Screen Voltage‡	500	500	500	750	Volts
D-c Plate Current	190	175	150	250	Milliamperes
Plate Input				600	Watts
Screen Grid Input				35	Watts
Plate Dissipation				400	Watts
Peak R-f Grid Input Voltage	250	245	215		Volts
Driving Power†, approx	20	15	15		Watts
Plate Power Output	140	160	175		Watts

‡ Use of series resistor not recommended.
† At crest of audio-frequency cycle.

				Typical Operation	Maximum Ratings*	

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR, PLATE-MODULATED
(Carrier conditions per tube for use with a maximum modulation factor of 1.0)

	Typical Operation			Maximum Ratings*	
Filament Voltage				11	Volts
D-c Plate Voltage	2000	2500	3000	3000	Volts
D-c Grid Voltage	-250	-225	-200	-800	Volts
D-c Screen Voltage	400	400	375	750	Volts
D-c Plate Current	250	220	200	300	Milliamperes
D-c Grid Current, approx	65	60	55	75	Milliamperes
Plate Input				650	Watts
Screen Grid Input				30	Watts
Plate Dissipation				270	Watts
Peak R-f Grid Input Voltage, approx	675	625	575		Volts
Driving Power, approx	0.045	0.040	0.035		Watts
Plate Power Output	285	340	400		Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
(Key down conditions per tube without modulation) Δ

	Typical Operation			Maximum Ratings*	
Filament Voltage				11	Volts
D-c Plate Voltage	2000	3000	3500	3500	Volts
D-c Grid Voltage	-250	-250	-250	-800	Volts
D-c Screen Voltage	500	500	500	750	Volts
D-c Plate Current	300	300	300	350	Milliamperes
D-c Grid Current	40	40	40	75	Milliamperes
Plate Input				1200	Watts
Plate Dissipation				400	Watts
Screen Grid Input				35	Watts
Peak R-f Grid Input Voltage, approx	725	725	725		Volts
Driving Power, approx	30	30	30		Watts
Plate Power Output	400	600	700		Watts

Δ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

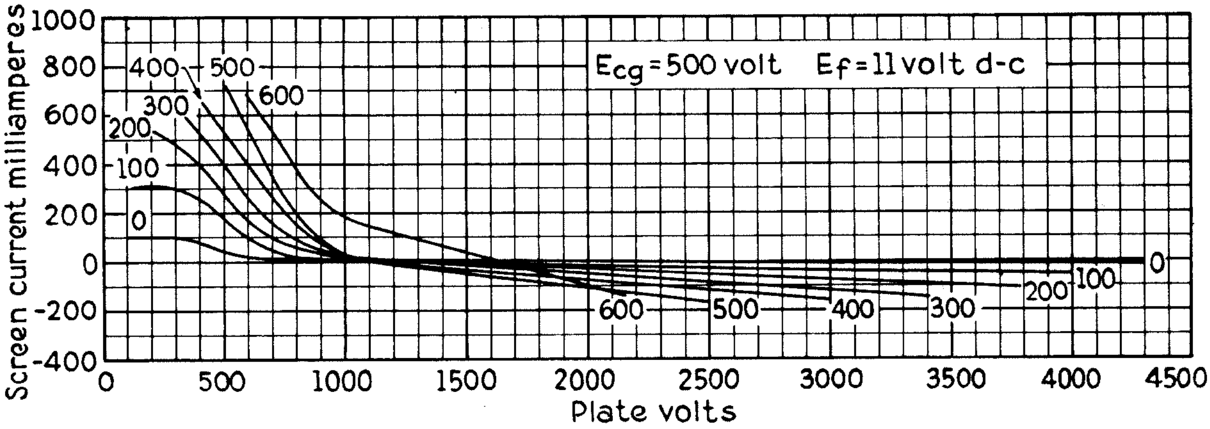
APPLICATION NOTES

*The GL-861 can be operated at frequencies as high as 20 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown above.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 60 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

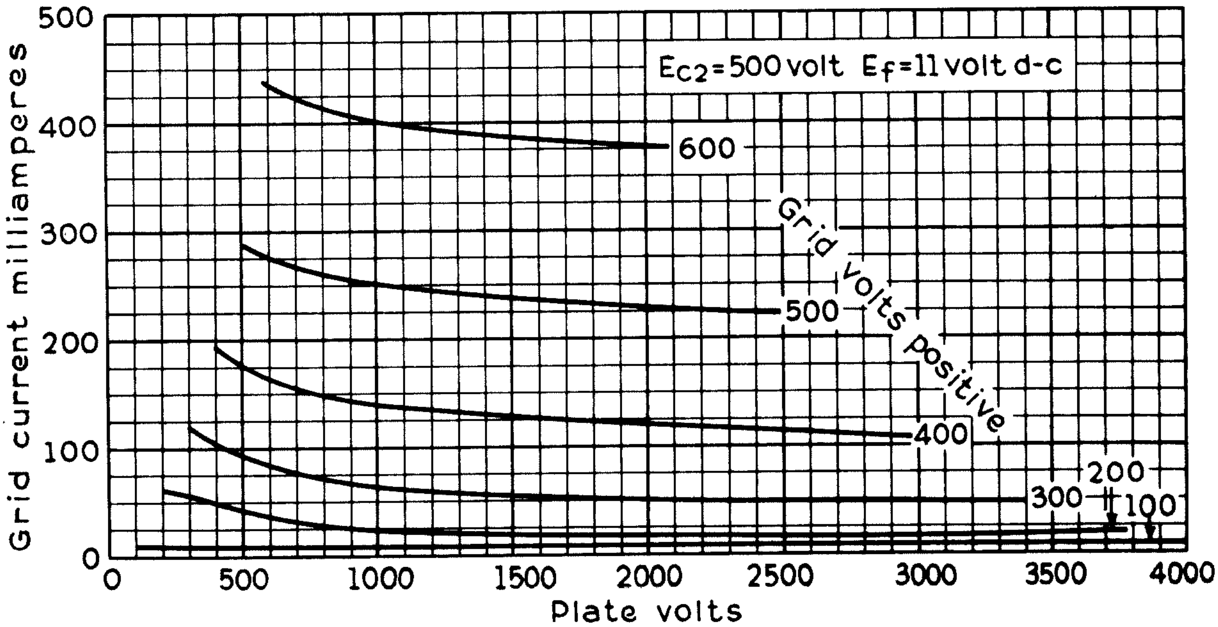
Frequency	20	30	60	Megacycles
Max Permissible Percentage of Max Rated Plate Voltage and Plate Input				
Class B, R-f	100	90	75	
Class C, Plate-modulated	100	82	53	
Telegraphy	100	82	53	

The resonant frequency of the grid-plate circuit is approximately 100 megacycles.

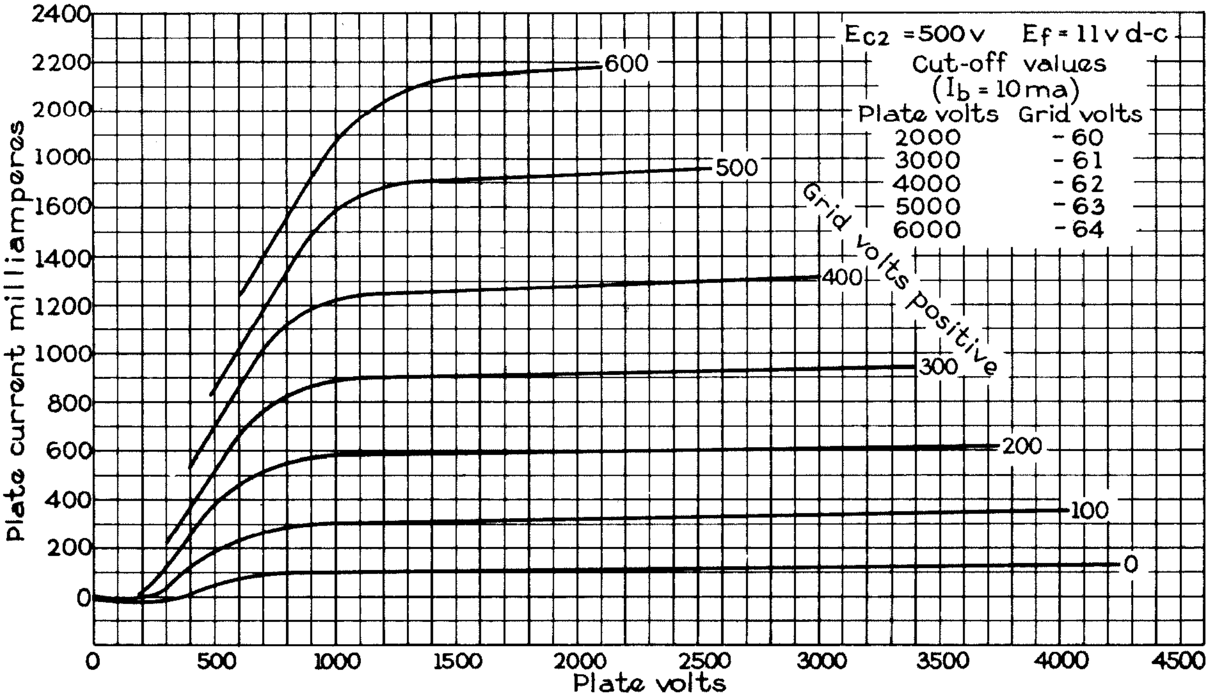
The normal value of grid leak, when the tube is used as an oscillator or r-f power amplifier (Class C), is in the neighborhood of 5000 ohms, although this may be replaced by a suitable fixed bias. If self-bias is used the cathode resistor should be approximately 500 ohms.



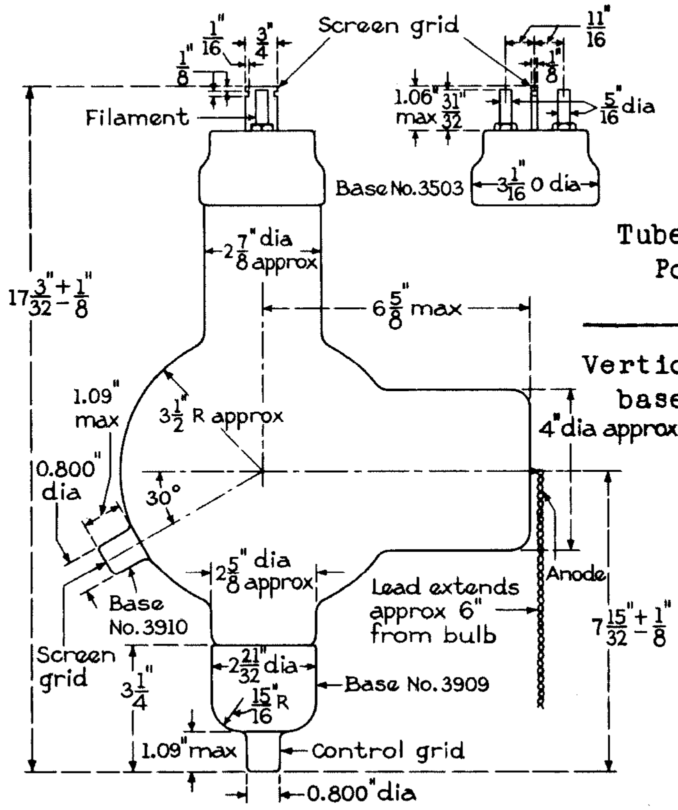
Average Plate-Screen-Grid Transfer Characteristics
K-6917429 for Transmitting Tube GL-861 10-2-39



Average Plate-Grid Transfer Characteristics
K-6917427 for Transmitting Tube GL-861 10-2-39



Average Plate Characteristics for Transmitting Tube GL-861
K-6917426 10-2-39



Tube Mounting Position

Vertical: Filament base up

Outline Transmitting Tube GL-861
K-4909033 12-13-39

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-862-A--Description and Rating

The 862-A is a three-electrode power tube designed for use as a radio-frequency amplifier, oscillator, or Class B modulator. The plate is water-cooled and is capable of dissipating 50 to 100 kilowatts, depending upon the class of service in which the tube is used.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament Voltage	33	Volts
Filament Current	207	Amperes
Amplification Factor	45	
Grid-plate Transconductance	17200	Micromhos
Direct Interelectrode Capacitances, mu mu f		
Grid-plate	69.5	
Input	53	
Output	4.5	
Frequency for Maximum Ratings	1.6	Megacycles

MECHANICAL

Base	6628	
Gasket	Cat. No. 5182028P1	
Type of Cooling	Water and Forced Air	
Water Flow, Max Outlet Temperature 70 C	15-25	Gallons/min
Air Flow, cubic feet per minute		
To Bulb	15	
To Stem	3	
Net Weight, approx	30	Pounds
Shipping Weight, approx	175	Pounds
Installation and Operation Instructions	GEH-1152	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B A-F POWER AMPLIFIER (TWO TUBES)	Typical Operation	Maximum Ratings	
D-c Plate Voltage	12000	15000	Volts
Maximum Signal Plate Current, per tube†		7.5	Amperes
D-c Maximum Signal Plate Input, per tube†		100	Kilowatts
Plate Dissipation†, per tube		50	Kilowatts
D-c Grid Voltage	0		Volts
Peak A-f Grid Input Voltage	2000		Volts
Zero Signal Plate Current	3		Amperes
Maximum Signal Plate Current	13		Amperes
Maximum Signal Plate Input†	156		Kilowatts
Maximum Signal Driving Power, approx	450		Watts
Effective Load, plate-to-plate	1800		Ohms
Maximum Signal Plate Power Output	90		Kilowatts

CLASS B R-F POWER AMPLIFIER

(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation			Maximum Ratings	
Filament Voltage					
D-c Plate Voltage	12000	15000	18000	20000	Volts
D-c Grid Voltage	-100	-150	-200		Volts
D-c Plate Current	2.8	3.5	4.2	5	Amperes
Plate Input				100	Kilowatts
Plate Dissipation				75	Kilowatts
Peak R-f Grid Input Voltage	500	625	750		Volts
Driving Power‡, approx	0.5	0.75	1.1		Kilowatts
Plate Power Output	11	17.5	25		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED

(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation			Maximum Ratings	
D-c Plate Voltage	8000	10000	12000	12000	Volts
D-c Grid Voltage	-700	-750	-800	-3000	Volts
D-c Plate Current	4	4.5	5	5	Amperes
D-c Grid Current, approx	1	1	1	1.25	Amperes
Plate Input				60	Kilowatts
Plate Dissipation				50	Kilowatts
Peak R-f Grid Input Voltage, approx	1700	1850	2000		Volts
Driving Power, approx	1.7	1.85	2		Kilowatts
Plate Power Output	24	34	45		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR

Key-down conditions per tube without modulation§

	Typical Operation			Maximum Ratings	
D-c Plate Voltage	12000	15000	18000	20000	Volts
D-c Grid Voltage	-800	-900	-1000	-3000	Volts
D-c Plate Current	6.25	7.5	8.33	10	Amperes
D-c Grid Current, approx	0.8	0.85	0.9	1	Ampere
Plate Input				200	Kilowatts
Plate Dissipation				100	Kilowatts
Peak R-f Grid Input Voltage, approx	2050	2300	2550		Volts
Driving Power, approx	1.6	2	2.4		Kilowatts
Plate Power Output	50	75	100		Kilowatts

APPLICATION NOTES

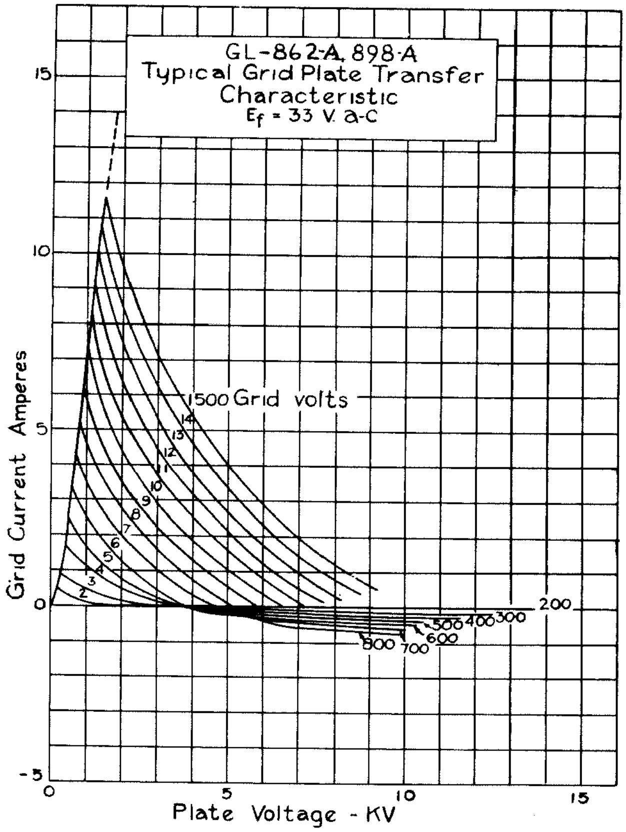
Plate Series Protective Resistors (see paragraph describing plate circuit under Installation in the Instructions)

Series Resistor, ohms	10	20	40	50
Maximum Power Output of Rectifier, kilowatts	100	250	640	1600

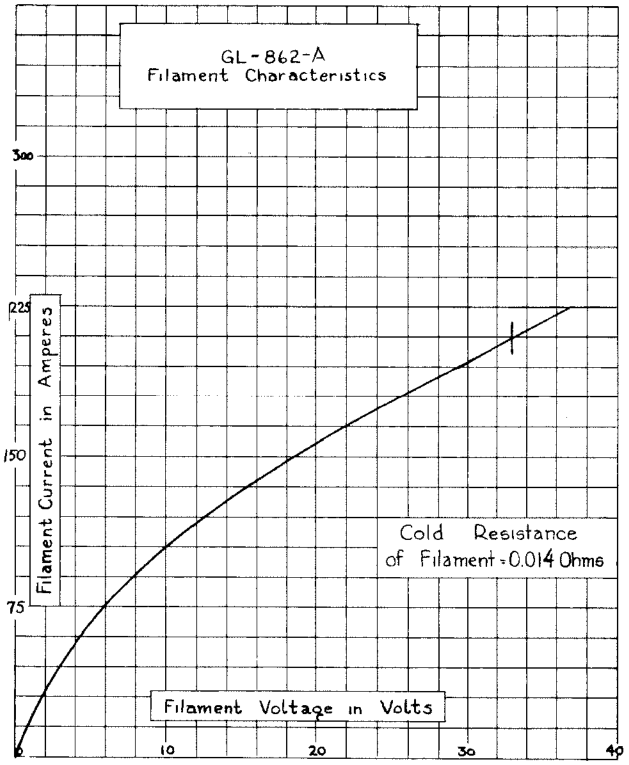
† Averaged over any audio-frequency cycle

‡ At crest of audio-frequency cycle

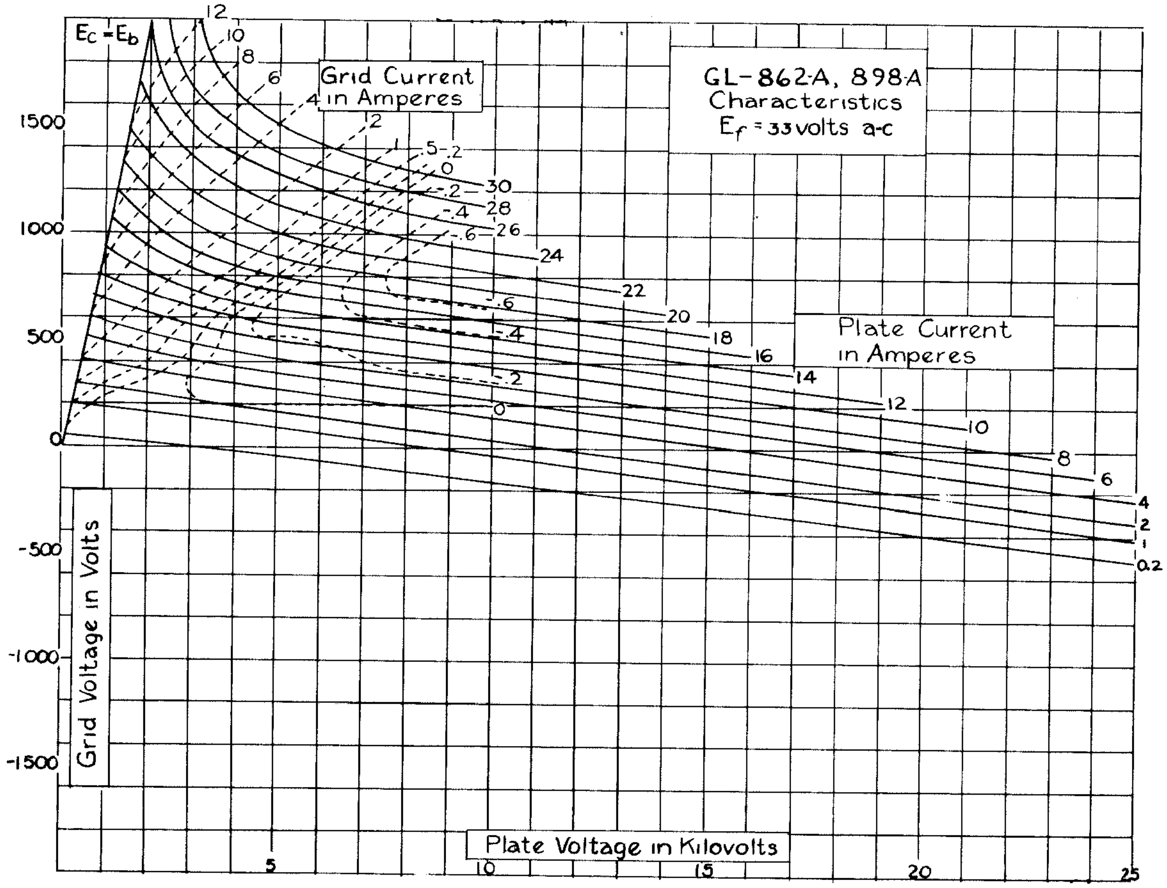
§ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.



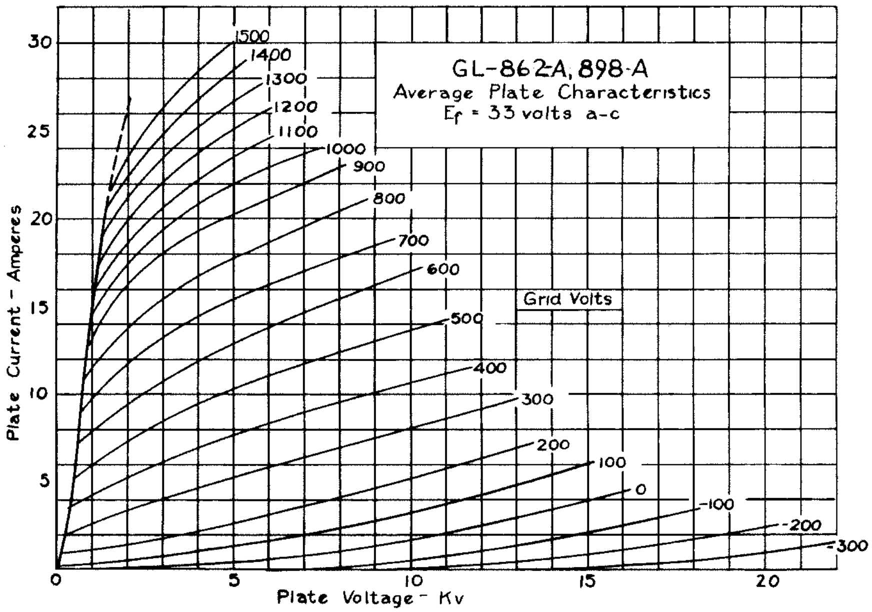
Typical Grid-plate Transfer
Characteristics for
Transmitting Tube GL-862-A
K-6966425 4-5-44



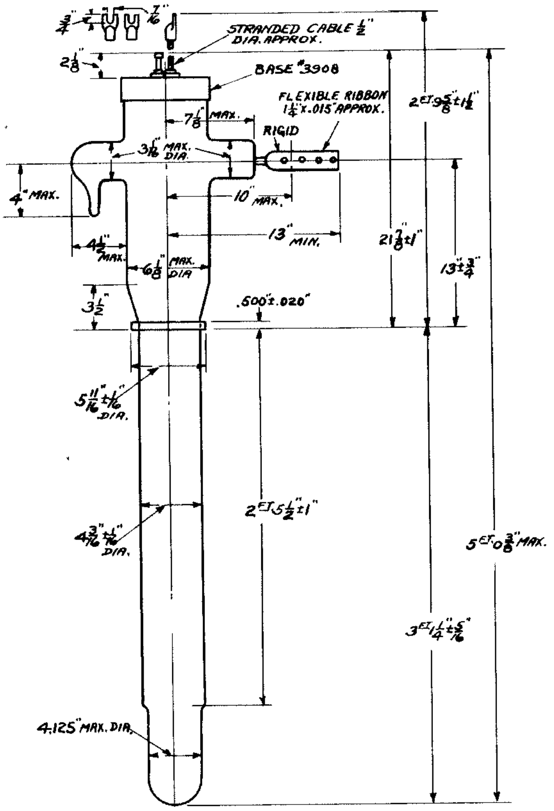
Filament Characteristics
Transmitting Tube 862-A
K-8074623 2-18-42



Characteristics for
Transmitting Tube GL-862-A
K-6966424 4-5-44



Average Plate Characteristics
K-6966423 4-5-44



Outline GL-862-A
K-3846052 4-26-39

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-866-A/866--Description and Rating

GL-866-A/866 is a half-wave, mercury-vapor rectifier, designed to withstand high peak inverse voltages and to conduct at relatively low applied voltages. The construction minimizes the danger of bulb cracks caused by corona discharge. An edgewise-wound ribbon filament provides a large emission reserve and improved life.

Two 866-A/866's operating in a full-wave rectifier are capable of delivering to the input of a choke-input filter a rectified voltage of 3180 volts at 0.5 ampere with good regulation.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Number of Electrodes	2	

Electrical

Cathode - Filamentary

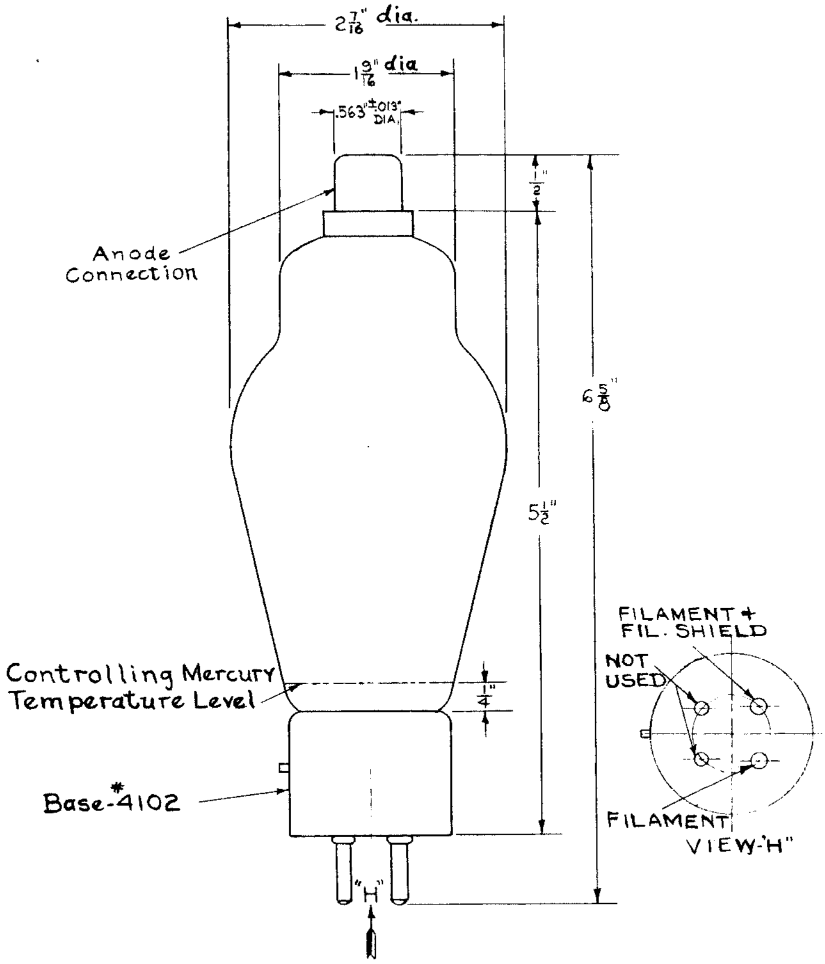
Filament Voltage	2.5	Volts
Filament Current, approximate	5	Amperes
Heating Time, typical	30	Seconds
Peak Voltage Drop, typical	15	Volts

Mechanical

Type of Cooling - Convection		
Net Weight, approximate	3	Ounces
Shipping Weight, approximate	3	Pounds
Installation and Operation - GEH-1196		

MAXIMUM RATINGS

Maximum Peak Inverse Anode Voltage			
150 Cycles per Second or Less	2000	10,000	Volts
Condensed-Mercury Temperature	25 to 70 C	25 to 60	C
1000 Cycles per Second or Less		5,000	Volts
Condensed-Mercury Temperature		25 to 70	C
Maximum Anode Current			
Instantaneous	2.0	1.0	Amperes
Average	0.5	0.25	Amperes
Recommended Temperature, Condensed-Mercury		40 ± 5	C



Outline Transmitting Tube GL-866-A/866
K-6966978 August 5, 1944

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-869-B--Description and Rating

The GL-869-B is a half-wave, mercury-vapor rectifier tube for use in broadcast transmitters and other applications where high d-c voltages are required. Economy of operation and high over-all efficiency result from several unique design features incorporated in this tube. The design of cathode used allows the further advantage of operation with both in-phase and quadrature filament excitation. In quadrature operation the filament and anode voltages are approximately ninety degrees out of phase with each other. Such an arrangement, allowing uniform utilization of the cathode, results in greater uniformity of characteristic than is possible with other methods, and in long tube life.

TECHNICAL INFORMATION

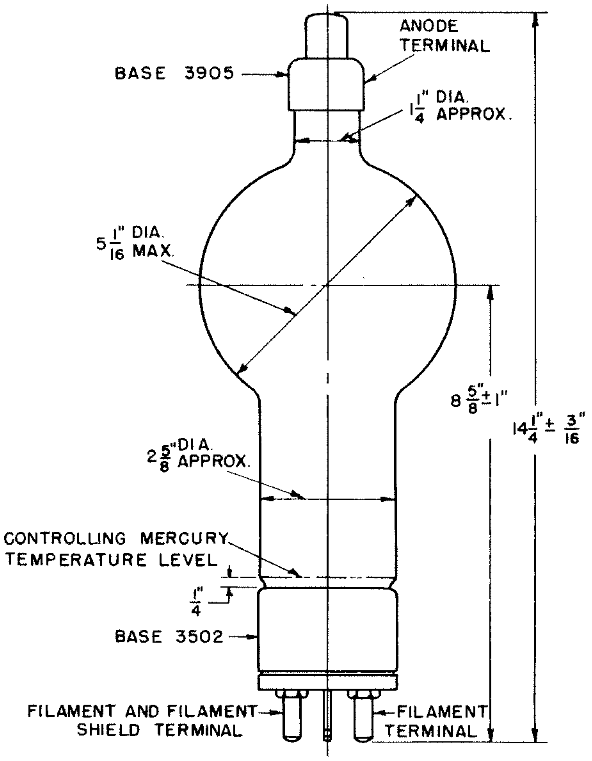
These data are for reference use only. For design information see the specifications.

GENERAL DESIGN

Number of Electrodes	2
Electrical	
Cathode - Filamentary	
Voltage	5.0 Volts
Current, approx	18.0 Amperes
Heating Time, typical	1 Minute
Peak Voltage Drop, Typical	15 Volts
Mechanical	
Type of Cooling - See Under Maximum Ratings	
Net Weight, approx	1 1/2 Pounds
Shipping Weight, approx	6 Pounds
Installation and Operation - GEH-977	

MAXIMUM RATINGS

	Condensed Mercury Temperature C	Type of Cooling	
In-phase Filament Excitation			
Maximum Peak Inverse Anode Voltage, 150 cycles or less	+30 to +40	Forced Ventilation	20,000 Volts
	+30 to +60	Natural Ventilation	10,000 Volts
Maximum Anode Current			
Instantaneous, 25 to 150 cycles			10 Amperes
Average			2.5 Amperes
Quadrature Filament Excitation			
Maximum Peak Inverse Anode Voltage, 150 cycles or less	+30 to +40	Forced Ventilation	15,000 Volts
Maximum Anode Current			
Instantaneous, 25 to 150 cycles			15.0 Amperes
Average			5.0 Amperes
Maximum Surge Anode Current for design only			100 Amperes
Duration of Surge Current			0.1 Seconds
Maximum Time of Averaging Current			30 Seconds
Recommended Tempeature, Condensed Mercury C			35±5



Outline GL-869 B
K-4909011 9-23-44

Tube Mounting Position

Vertical: Base down

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-870-A--Description and Rating

The GL-870-A is a half-wave, mercury-vapor rectifier tube containing a heater-cathode of the equipotential type. The cathode consists of a coated cylinder heated by means of an enclosed tungsten filament (heater). The cathode is connected to one side of the heater within the tube.

TECHNICAL INFORMATION

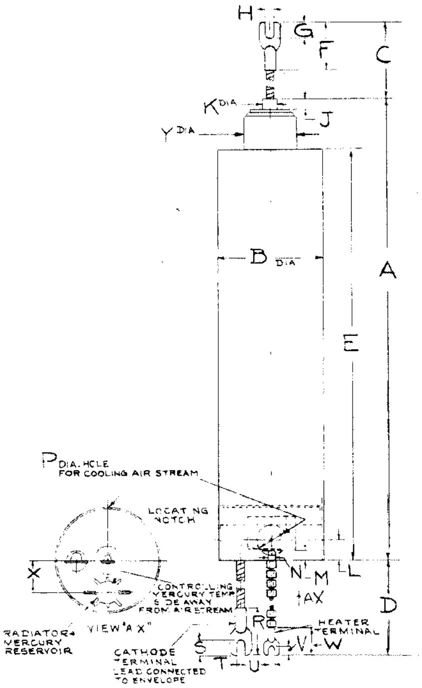
These data are for reference only. For design information see the specifications.

GENERAL DESIGN

Number of Electrodes	2
Cathode, Type	Coated Unipotential Cathode
Voltage, volts	5.0
Current, amperes approx	65.0
Transformer Watts, for design purposes	400
Heating Time, typical, min	30
Tube Voltage Drop, volts	
Maximum	20
Minimum	5
Net Weight, pounds approx	25
Shipping Weight, pounds approx	40
Installation and Operation	GEH-977

MAXIMUM RATINGS

Maximum Peak Inverse Anode Voltage, volts	
150 cycles or less	
Condensed-Mercury temperature 35 - 40 C	16000
Condensed-Mercury temperature 35 - 50 C	7500
Type of Cooling	Forced Air
Maximum Anode Current, amperes	
Instantaneous, 25 cycles and above	450
Average	75
Surge, for design only	4500
Maximum Time of Averaging Current, seconds	60
Maximum Time of Surge Anode Current, seconds	0.2
Recommended Temperature, Condensed Mercury, C	35 - 40



	MAX	MIN
A	26.13"	25.13"
B	5.56"	5.44"
C	7.63"	6.88"
D	13"	12"
E	23.5"	22.5"
F	2.69"	2.56"
G	0.78"	0.73"
H	0.45"	0.42"
J	0.75"	0.63"
K	0.78"	0.73"
L	1.09"	1.03"
M	0.40"	0.34"
N	0.27"	0.23"
P	1.65"	1.59"
R	2.69"	2.56"
S	0.78"	0.73"
T	0.45"	0.42"
U	0.38"	0.31"
V	0.65"	0.60"
W	1.53"	1.47"
X	1.75"	1.63"
Y	2.63"	2.38"

3-44 (5M)
Filing No. 8850

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-872-A/872—Description and Rating

The 872-A/872 is a half-wave, mercury-vapor rectifier tube designed to withstand high peak inverse voltages, and to conduct at relatively low applied voltages.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL DESIGN

Electrical

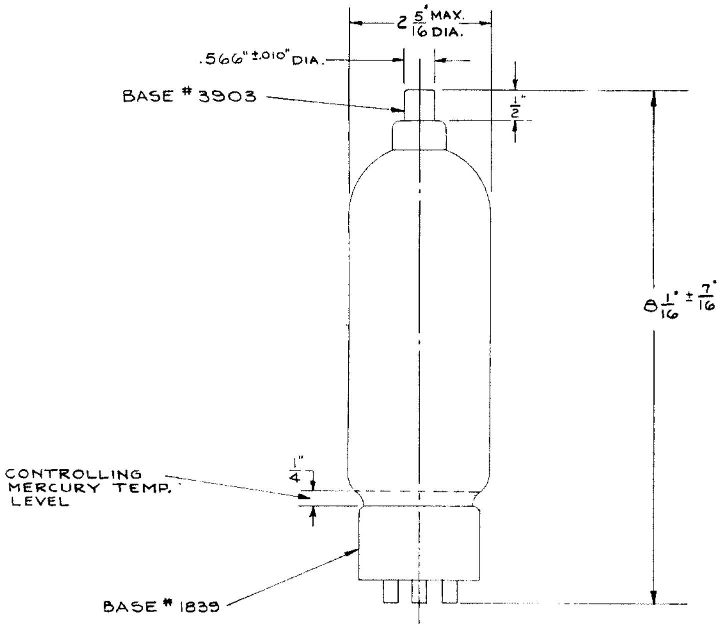
Number of Electrodes	2	
Cathode Type		Filamentary
Voltage	5.0	Volts
Current, approx	7.5	Amperes
Transformer Watts, for design purposes	50	
Heating Time, Typical	30	Seconds
Approximate Tube Voltage Drop	10	Volts

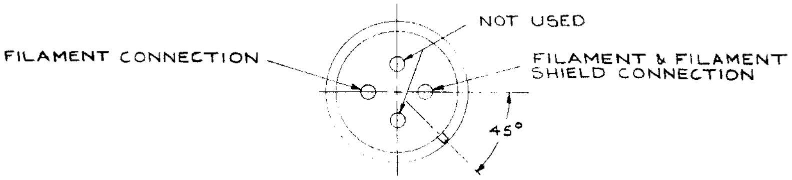
Mechanical

Type of Cooling	Convection
Recommended Temperature, Condensed Mercury	40 ± 5 C
Mounting Position	Vertical, Base Down
Base	Jumbo 4-pin, 1839
Cap	Medium Metal, RMA M8-126
Net Weight, approx	1/2 Pound
Shipping Weight, approx	3 Pounds
Installation and Operation	GEH-977

MAXIMUM RATINGS

Maximum Peak Inverse Anode Voltage		
150 cycles or less	5,000	Volts
Corresponding Condensed-Mercury Temperature Limits	20 - 70	C
Maximum Peak Inverse Anode Voltage		
150 cycles or less	10,000	Volts
Corresponding Condensed-Mercury Temperature Limits	20 - 60	C
Maximum Anode Current		
Instantaneous		
25 cycles and above	5.0	Amperes
Average	1.25	Amperes
Surge, for design only	50	Amperes
Maximum Time of Averaging Current	15	Seconds
Maximum Time of Surge Anode Current	0.2	Second





BOTTOM VIEW OF BASE

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-880--Description and Rating

TECHNICAL INFORMATION

The 880 is a three-electrode power tube designed for use as a radio-frequency amplifier, oscillator, or Class B modulator. The plate is water-cooled and is capable of dissipating 12 to 20 kw, depending upon the class of service. The design of the terminal mount connections and the introverted anode minimize lead inductance and make the tube particularly suitable for high-frequency applications.

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS:

ELECTRICAL	
Filament Voltage	12.6 Volts
Filament Current	320 Amperes
Amplification Factor	20
Grid-plate Transconductance, I_b = 2.0	21000 Micromhos
Direct Interelectrode Capacitances, mu mu f	
Grid-plate	24
Grid-filament	35
Plate-filament	2
MECHANICAL	
Gasket	Cat. No. P5182028P1
Type of Cooling	Water and Forced Air
Water Flow	12-20 Gallons per minute
Air Flow	
To Bulb, from a 3-inch Diam Nozzle	20 Cubic feet per minute
Net Weight	7 Pounds
Shipping Weight, approx	21 Pounds
Installation and Operation - ET-H1	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B A-F POWER AMPLIFIER (TWO TUBES):

	Typical Operation		Maximum* Ratings	
D-c Plate Voltage	7500	10000	10500	Volts
Max Signal Plate Current (per tube)†			5	Amperes
D-c Max Signal Plate Input (per tube)†			40	Kilowatts
Plate Dissipation (per tube)†			15	Kilowatts
D-c Grid Voltage	-300	-430		Volts
Peak A-f Grid Input Voltage	1450	1690		Volts
Zero Signal Plate Current	1.0	1.0		Amperes
Max Signal Plate Current	7.0	7.0		Amperes
Max Signal Plate Input†	52	70		Kilowatts
Max Signal Driving Power, approx	250	225		Watts
Effective Load (plate-to-plate)	2200	3200		Ohms
Max Signal Plate Power Output	30	45		Kilowatts

	Typical Operation		Maximum* Ratings	
CLASS B R-F POWER AMPLIFIER: Carrier conditions per tube for use with a max modulation factor of 1.0				
D-c Plate Voltage	7500	10000	10500	Volts
D-c Grid Voltage	-310	-430		Volts
D-c Plate Current	3.5	3	4	Amperes
Plate Input			32	Kilowatts
Plate Dissipation			20	Kilowatts
Peak R-f Grid Input Voltage	450	550		Volts
Driving Power‡, approx	500	500		Watts
Plate Power Output	8	10		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE-MODULATED:
Carrier conditions per tube for use with a max modulation factor of 1.0

	Typical Operation		Maximum* Ratings	
D-c Plate Voltage	7500	10000	10500	Volts
D-c Grid Voltage	-1000	-1200	-1200	Volts
D-c Plate Current	3.0	3.6	3.6	Amperes
D-c Grid Current, approx	0.3	0.5	0.8	Amperes
Plate Input			36	Watts
Plate Dissipation			12	Kilowatts
Peak R-f Grid Input Voltage, approx	1550	1770		Volts
Driving Power, approx	460	880		Watts
Plate Power Output	16	28		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR:
Key-down conditions per tube without modulation§

	Typical Operation			Maximum* Ratings	
D-c Plate Voltage	7500	10000	10000	10500	Volts
D-c Grid Voltage	-600	-800	-800	-1200	Volts
D-c Plate Current	5	4.5	6	6	Amperes
D-c Grid Current, approx	0.45	0.4	0.5	0.8	Amperes
Plate Input				60	Kilowatts
Plate Dissipation				20	Kilowatts
Peak R-f Grid Input Voltage, approx	1250	1400	1500		Volts
Driving Power, approx	560	550	750		Watts
Plate Power Output	27	34	45		Kilowatts

† Averaged over any audio-frequency cycle.
‡ At crest of audio-frequency cycle.
§ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

APPLICATION NOTES

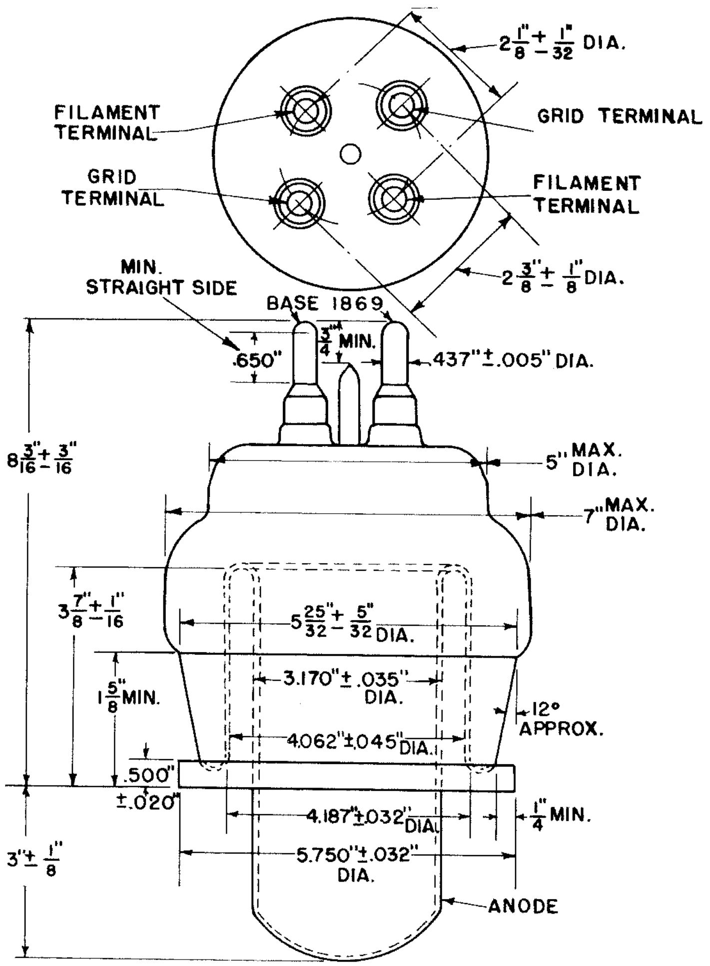
* The GL-880 can be operated at maximum ratings in all classes of service at frequencies as high as 25 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown above.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 100 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

Frequency - Mc	25	50	75	100
Class B R-f				
Per Cent Max Plate Voltage	100	80	68	60
Per Cent Max Plate Input	100	94	85	75

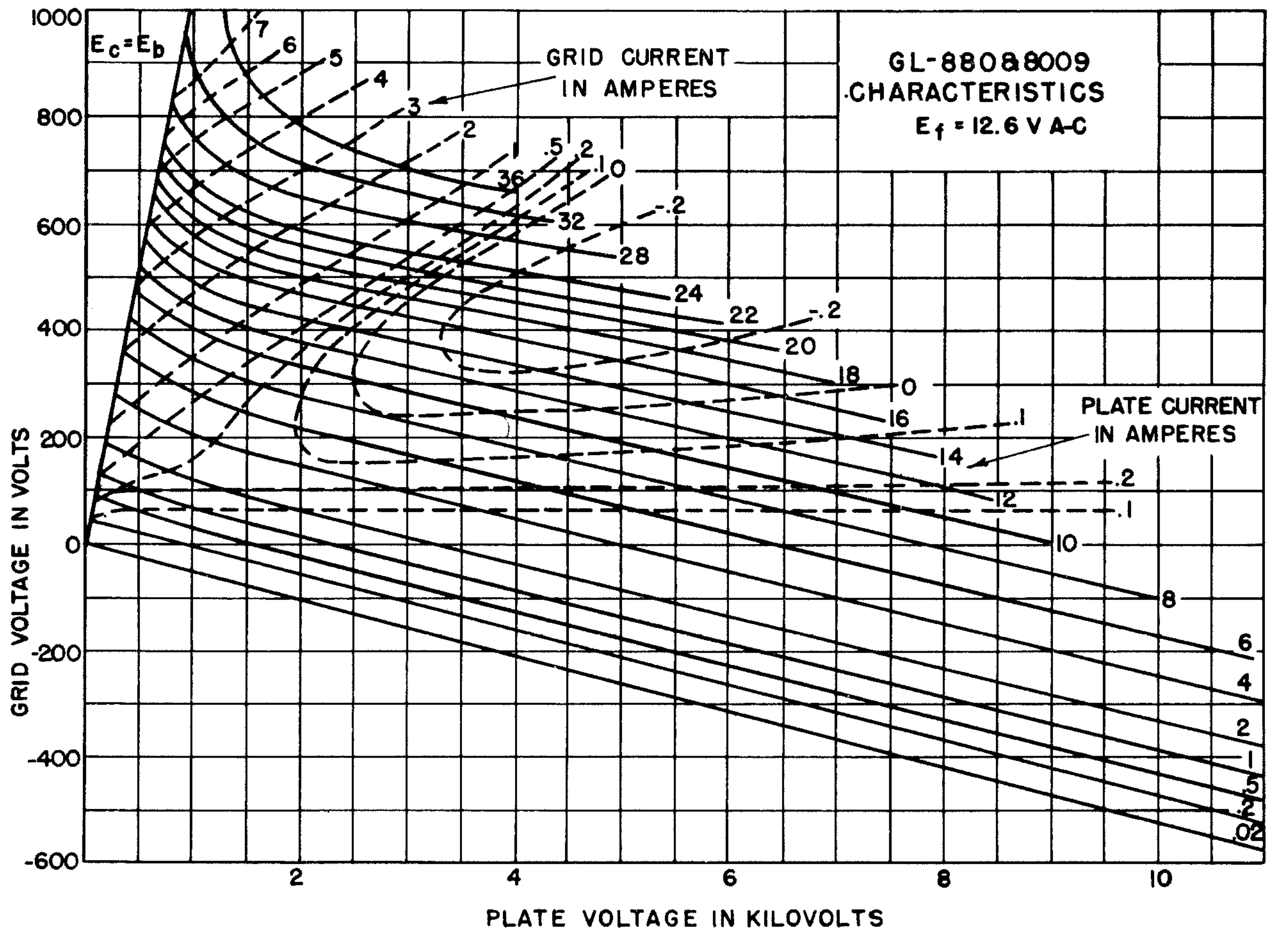
Class C Plate-modulated				
Per Cent Max Plate Voltage and Plate Input	100	72	56	45
Class C				
Per Cent Max Plate Voltage and Plate Input	100	75	62	50

Plate Series Protective Resistors (See paragraph describing plate circuit under Installation in the Instructions)

Series Resistor, ohms	10	15	20	30
Maximum Power Output of Rectifier, kilowatts	40	100	250	640



Outline Transmitting Tube
GL-880
K-5965320 9-23-44



Characteristic Curve
K-8074621 9-26-44

PRINTED IN U.S.A.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-889--Description and Rating

The GL-889 is a power tube designed for use as a radio-frequency, amplifier, oscillator, or Class B modulator. The plate is water-cooled and is capable of dissipating 3 to 5 kilowatts, depending upon the class of service. The design of the mount and terminal connections minimizes lead inductance and makes the tube particularly suitable for high-frequency radio broadcast and industrial heating applications.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Number of Electrodes	3
ELECTRICAL	
Cathode-Filamentary	
Filament Voltage	11 Volts
Filament Current	125 Amperes
Amplification Factor, E_b = 5 kv, I_b = 1.0 amp, E_c = 75 v, E_f = 11 v a-c	21
Grid-plate Transconductance	9000 Micromhos
Direct Interelectrode Capacitances,	
Grid-plate	17.5
Grid-filament	23.3
Plate-filament	2.7
Frequency for Maximum Ratings	50 Megacycles
MECHANICAL	
Type of Cooling - Water and Forced Air	
Water Flow	3 - 6 Gallons per Minute
Air Flow	
To Bulb, from a 3-inch diam nozzle	15 Cubic Feet per Minute
Gasket	Cat. No. 5182028P8
Net Weight, approx	2 Pounds
Shipping Weight, approx	9 Pounds
Instructions	ET-H1

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B AUDIO-FREQUENCY POWER AMPLIFIER (TWO TUBES):

	Typical Operation			Maximum* Ratings	
D-c Plate Voltage	5000	6000	7500	8500	Volts
Maximum Signal Plate Current, per tube†				2.0	Amperes
D-c Maximum Signal Plate Input, per tube†				12	Kilowatts
Plate Dissipation, per tube†				5.0	Kilowatts
D-c Grid Voltage	-180	-230	-300		Volts

CLASS B AUDIO-FREQUENCY POWER AMPLIFIER (TWO TUBES): (CONT'D)

	Typical Operation			Maximum* Ratings	
Peak A-f Grid Input Voltage	1460	1680	1700		Volts
Zero Signal Plate Current	0.4	0.4	0.4		Amperes
Maximum Signal Plate Current	3.2	3.6	3.2		Amperes
Maximum Signal Plate Input†	16	21.6	24		Kilowatts
Maximum Signal Driving Power, approx	170	180	150		Watts
Effective Load, plate-to-plate	2520	3680	5000		Ohms
Maximum Signal Plate Power Output	8.8	12	15		Kilowatts

CLASS B RADIO-FREQUENCY POWER AMPLIFIER
Carrier conditions per tube for use with a max modulation factor of 1.0.

D-c Plate Voltage		6000	7500	8500	Volts
D-c Grid Voltage		-250	-300		Volts
D-c Plate Current		0.9	0.9	1.0	Amperes
Plate Input				7.5	Kilowatts
Plate Dissipation				5.0	Kilowatts
Peak R-f Grid Input Voltage		920	1000		Volts
Driving Power, approx‡		95	80		Watts
Plate Power Output		1.5	2		Kilowatts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR - PLATE-MODULATED
Carrier conditions per tube for use with a max modulation factor of 1.0.

D-c Plate Voltage		5000	6000	6000	Volts
D-c Grid Voltage		-800	-900	-1000	Volts
D-c Plate Current		0.9	1.0	1.0	Amperes
D-c Grid Current, approx		0.12	0.1	0.25	Amperes
Plate Input				6.0	Kilowatts
Plate Dissipation				3.0	Kilowatts
Peak R-f Grid Input Voltage, approx		1300	1420		Volts
Driving Power, approx		155	140		Watts
Plate Power Output		2.75	4.0		Kilowatts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR
Key-down conditions per tube without modulationπ.

D-c Plate Voltage	5000	6000	7500	8500	Volts
D-c Grid Voltage	-500	-600	-800	-1000	Volts
D-c Plate Current	1.5	1.8	2.0	2.0	Amperes
D-c Grid Current, approx	0.19	0.21	0.24	0.25	Amperes
Plate Input				16	Kilowatts
Plate Dissipation				5	Kilowatts
Peak R-f Grid Input Voltage, approx	1200	1460	1830		Volts
Driving Power, approx	220	290	400		Watts
Plate Power Output	5	7	10		Kilowatts

† Averaged over any audio-frequency cycle.
‡ At crest of audio-frequency cycle.
π Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

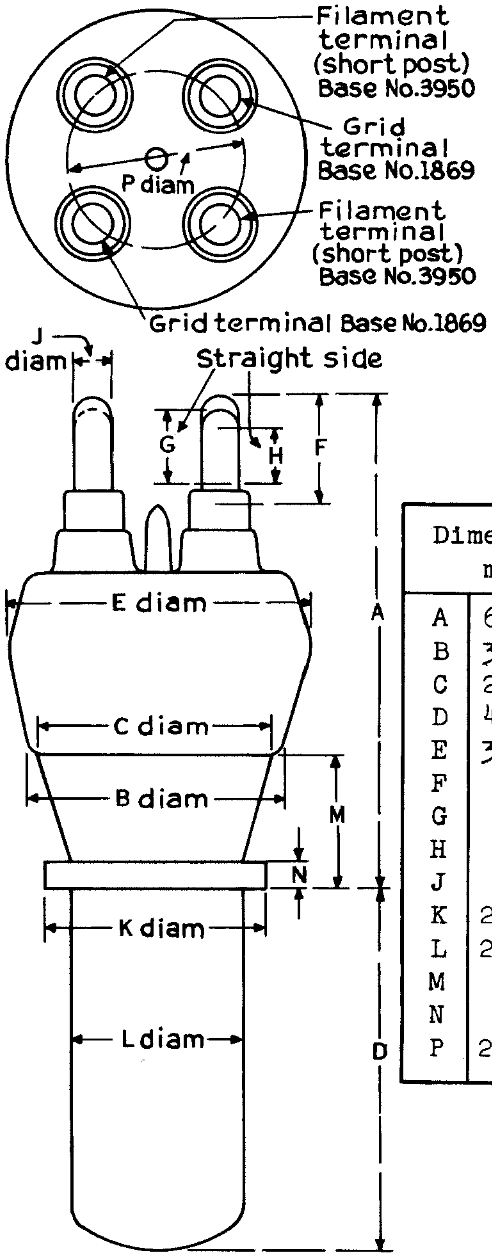
APPLICATION NOTES

* GL-889 can be operated at maximum ratings in all classes of service at frequencies as high as 50 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under TECHNICAL INFORMATION.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 150 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

Frequency - Mc	50	75	100	150
Class B R-f				
Per Cent Max Plate Voltage and Plate Input	100	90	83	72
Class C Plate-modulated				
Per Cent Max Plate Voltage and Plate Input	100	85	75	60
Class C				
Per Cent Max Plate Voltage	100	87	78	65
Per Cent Max Plate Input	100	85	70	50

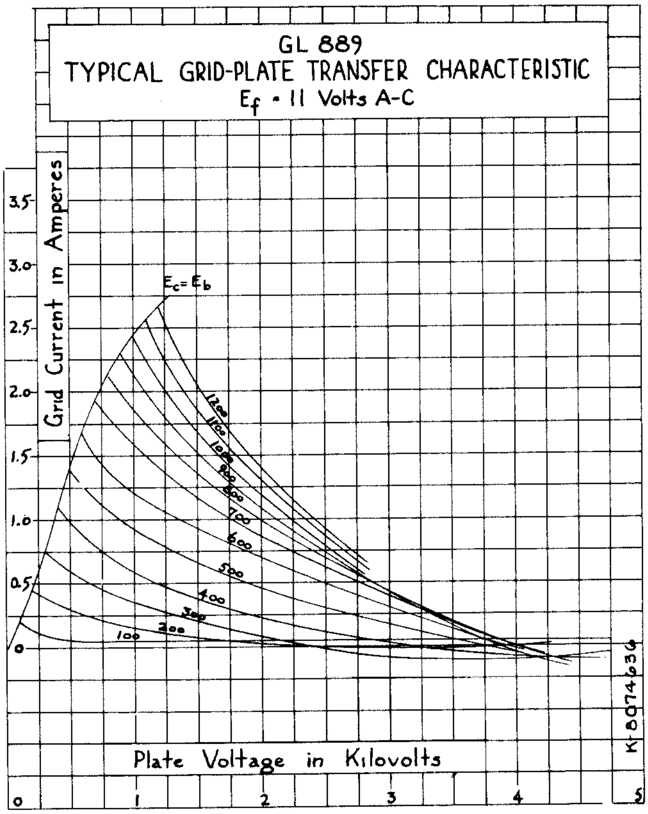
Plate Series Protective Resistors (See paragraph describing plate circuit under Installation in the Instructions)

Series Resistor, ohms	25	50	100	150
Maximum Power Output of Rectifier, kilowatts	16	40	100	250

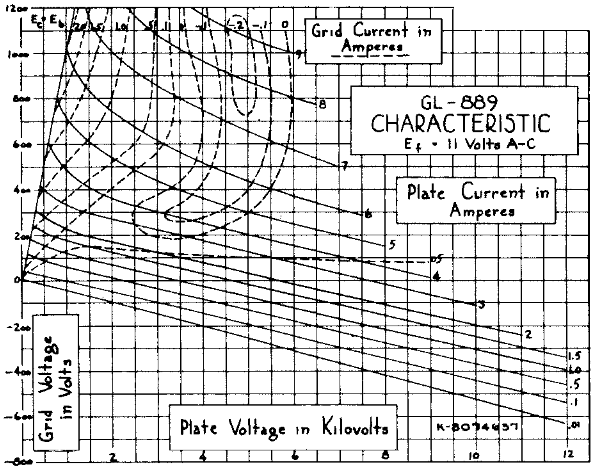


Dimensions in Inches	max	min
A	6 3/16	5 13/16
B	3 1/4	
C	2 7/8	
D	4.44	4.31
E	3 5/8	
F		3/4
G		.650
H		.465
J	.442	.432
K	2.702	2.672
L	2.052	1.992
M		1 5/8
N	.322	.302
P	2 5/32	2 3/32

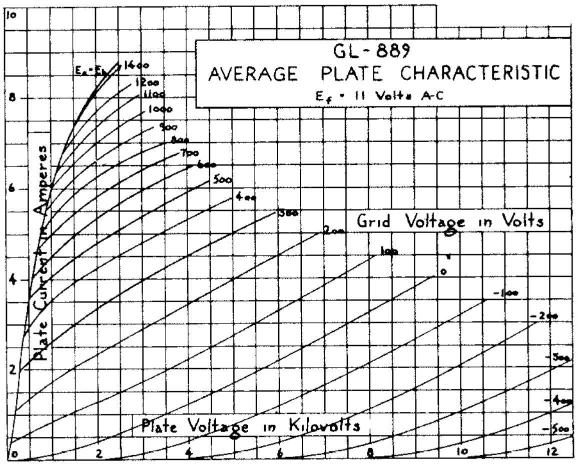
Outline Transmitting Tube GL-889
K-5344713 5-15-39



Typical Grid Plate Transfer
Characteristics for Transmitting
Tube GL-889
K-8074636 6-25-43



Characteristics for Transmitting
Tube GL-889
K-8074637 6-25-43



Average Plate Characteristics
for Transmitting Tube GL-889
K-8074635 6-23-43

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-889-R--Description and Rating

The 889-R is a three-electrode power tube designed for use as a radio-frequency amplifier, oscillator, or Class B modulator. The plate is fitted with a special radiator and cooling is obtained by forced air. The design of the mount and terminal connections minimizes lead inductance and makes the tube particularly suitable for high-frequency applications.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Number of Electrodes — 3

Electrical

Cathode - filamentary
- Filament Voltage — 11 Volts
- Filament Current — 125 Amperes

Average Characteristics, Eb = 5 kv Ib = 1.0 amp
E_f = 11 volts a-c
- Grid Voltage — 75 Volts
- Amplification Factor — 21
- Grid-plate Transconductance, I_b = 1.0 amp — 9000 Micromhos

Direct Interelectrode Capacitances
- Grid-plate — 18.5 μuf
- Grid-filament — 23.3 μuf
- Plate-filament — 3.0 μuf

Frequency for Maximum Ratings — 25 Megacycles

Mechanical

Type of Cooling - Forced-air
- Maximum Incoming Air Temperature 50 C
- Flow
  - To Radiator — 500 Cubic feet per minute
  - To Bulb, from a 3-inch diameter nozzle — 15 Cubic feet per minute

Net Weight, approximate — 35 Pounds
Shipping Weight, approximate — 52 Pounds
Installation and Operation - ET-H13

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B A-F POWER AMPLIFIER (TWO TUBES):

	Typical Operation			Maximum* Ratings	
D-c Plate Voltage	5000	6000	7500	8500	Volts
Maximum Signal Plate Current, per tube†				2.0	Amperes
D-c Maximum Signal Plate Input, per tube†				12	Kilowatts
Plate Dissipation, per tube†				5.0	Kilowatts

CLASS B A-F POWER AMPLIFIER (TWO TUBES): (Cont'd)

	Typical Operation			Maximum* Ratings	
Radiator Temperature‡				180	C
D-c Grid Voltage	-180	-230	-300		Volts
Peak A-f Grid Input Voltage	1460	1680	1700		Volts
Zero Signal Plate Current	0.4	0.4	0.4		Amperes
Maximum Signal Plate Current	3.2	3.6	3.2		Amperes
Maximum Signal Plate Input†	16	21.6	24		Kilowatts
Maximum Signal Driving Power, approx	170	180	150		Watts
Effective Load, plate-to-plate	2520	3680	5000		Ohms
Maximum Signal Plate Power Output	8.8	12	15		Kilowatts

CLASS B R-F POWER AMPLIFIER
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	6000	7500	8500	Volts
D-c Grid Voltage	-250	-300		Volts
D-c Plate Current	0.9	0.9	1.0	Amperes
Plate Input			7.5	Kilowatts
Plate Dissipation			5.0	Kilowatts
Radiator Temperature‡			180	C
Peak R-f Grid Input Voltage	920	1000		Volts
D-c Grid Current				
Driving Power, approx§	95	80		Watts
Plate Power Output, approximate	1.5	2		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE-MODULATED
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	5000	6000	6000	Volts
D-c Grid Voltage	-800	-900	-1000	Volts
D-c Plate Current	0.9	1.0	1.0	Amperes
D-c Grid Current, approx	0.12	0.1	0.25	Amperes
Plate Input			6.0	Kilowatts
Plate Dissipation			3.0	Kilowatts
Radiator Temperature‡ (modulation factor m = 1.0)			180	C
Peak R-f Grid Input Voltage, approx	1300	1420		Volts
Driving Power, approx	155	140		Watts
Plate Power Output	2.75	4.0		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
Key-down conditions per tube without modulation π

D-c Plate Voltage	5000	6000	7500	8500	Volts
D-c Grid Voltage	-500	-600	-800	-1000	Volts
D-c Plate Current	1.5	1.8	2.0	2.0	Amperes
D-c Grid Current, approx	0.19	0.21	0.24	0.25	Amperes
Plate Input				16	Kilowatts
Plate Dissipation				5	Kilowatts
Radiator Temperature‡				180	C
Peak R-f Grid Input Voltage, approx	1200	1460	1830		Volts
Driving Power, approx	220	290	400		Watts
Plate Power Output, approximate	5	7	10		Kilowatts

† Averaged over any audio-frequency cycle.

‡ This temperature corresponds to the maximum ratings when the air flow is 500 cubic feet per minute and the temperature of the incoming air does not exceed 45 C. The glass temperature must not be allowed to exceed 150 C.

§ At crest of audio-frequency cycle.

π Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

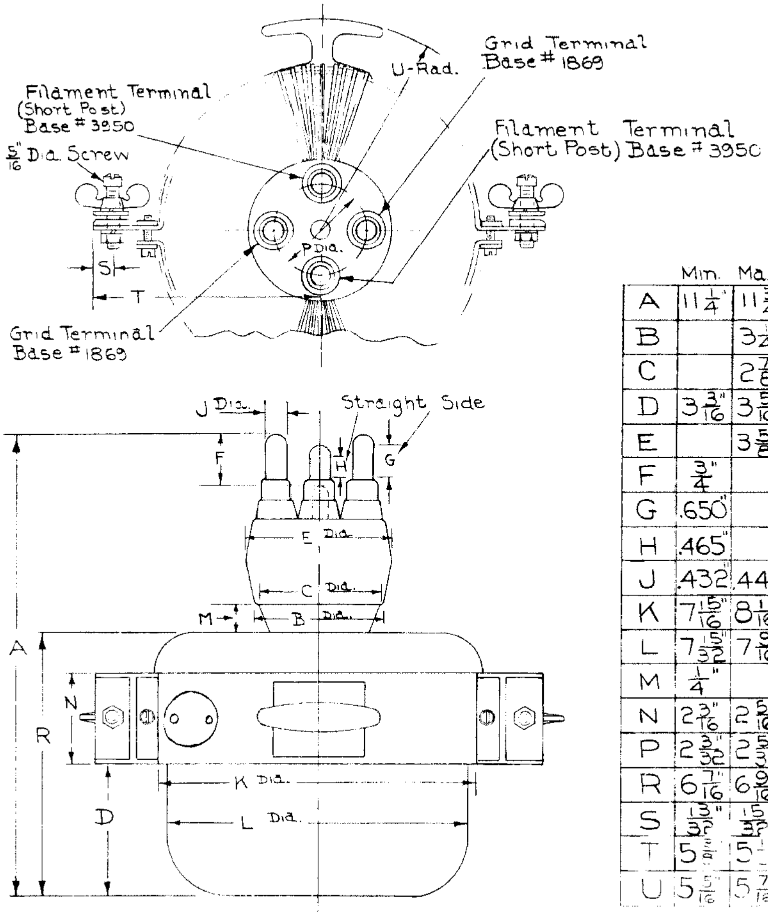
APPLICATION NOTES

* GL-889-R can be operated at maximum ratings in all classes of service at frequencies as high as 25 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under TECHNICAL INFORMATION.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 100 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

Frequency - Mc	25	50	75	100
Class B R-f				
Per Cent Max Plate Voltage and Plate Input	100	87	80	74
Class C Plate-modulated				
Per Cent Max Plate Voltage and Plate Input	100	80	68	60
Class C				
Per Cent Max Plate Voltage	100	85	76	70
Per Cent Max Plate Input	100	75	60	50

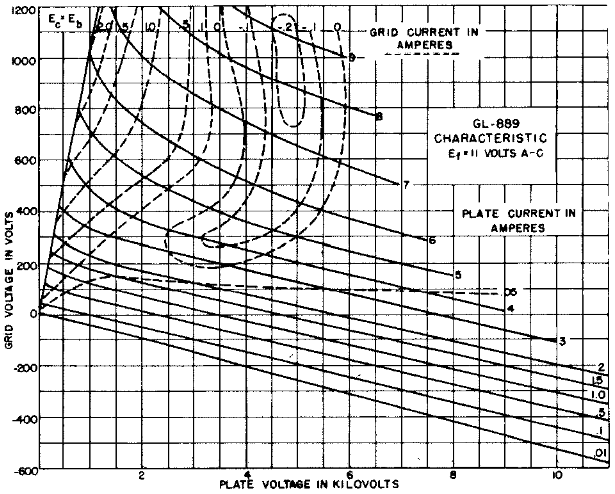
Plate Series Protective Resistors (See paragraph describing plate circuit under Installation in the Instructions)

Series Resistor, ohms	25	50	100	150
Maximum Power Output of Rectifier, kilowatts	16	40	100	250

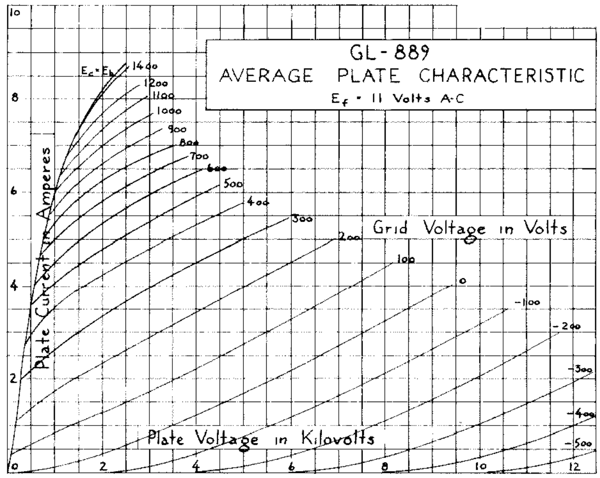


	Min.	Max.
A	11 1/4"	11 3/4"
B		3 1/4"
C		2 7/8"
D	3 3/16"	3 5/16"
E		3 5/8"
F	3/4"	
G	.650"	
H	.465"	
J	.432"	.442"
K	7 15/16"	8 1/16"
L	7 15/32"	7 9/16"
M	1/4"	
N	2 3/16"	2 5/16"
P	2 3/32"	2 5/32"
R	6 7/16"	6 9/16"
S	13/32"	15/32"
T	5 [illegible]	5 [illegible]
U	5 5/16"	5 7/16"

Outline Transmitting Tube GL-889-R
K-6966908 11-25-43

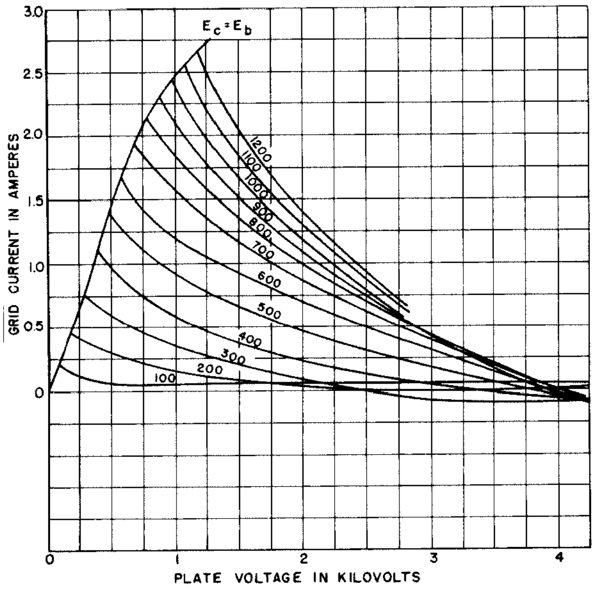


Characteristics for Transmitting
Tube GL-889-R
K-8074637 9-26-44



Average Plate Characteristics
for Transmitting Tube GL-889-R
K-8074635 6-25-43

GL-889
TYPICAL GRID-PLATE TRANSFER CHARACTERISTIC
E_f = 11 VOLTS A-C



Typical Grid Plate Transfer
Characteristics for Transmitting
Tube GL-889-R
K-8074636 9-26-44

ELECTRONICS DEPARTMENT
GENERAL ELECTRIC

Transmitting Tube GL-891--Description and Rating

The 891 is a three-electrode transmitting tube of the double-filament type for use as a radio-frequency power amplifier, oscillator, Class A modulator and Class B modulator. The construction of the filament permits operation from two-phase or single-phase alternating current as well as from direct current, for all classes of service. The plate is water-cooled and is capable of dissipating 4 to 7.5 kilowatts, depending on the service in which the tube is used.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Electrical

Filament	Tungsten, Two-unit Type	
Excitation	1ø a-c, 2ø a-c, or d-c	
Voltage per Unit	11	Volts
Current per Unit	60	Amperes
Amplification Factor	8	
Direct Interelectrode Capacitances, approx:		
Grid-plate	27	μμf
Grid-filament	18	μμf
Plate-filament	2	μμf

Mechanical

Cooling: Water flow of 3 to 8 gallons per minute must start before application of any voltages and continue for at least 5 minutes after removal of voltages. Water temperature must not exceed 70 C under any conditions of operation.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS A A-F POWER AMPLIFIER AND MODULATOR

	Typical Operation	Maximum Ratings	
D-c Plate Voltage		12000	Volts
Plate Input		7.5	Kilowatts
Plate Dissipation		7.5	Kilowatts
D-c Voltage	8000		Volts
D-c Grid Voltage*	-630		Volts
Peak A-f Grid Voltage	700		Volts
D-c Plate Current	0.9		Ampere
Load Resistance	5200		Ohms
U.P.O. (5% second harmonic)	2		Kilowatts

CLASS B A-F POWER AMPLIFIER AND MODULATOR

D-c Plate Voltage				15000	Volts
Max Signal D-c Plate Current†				2.0	Amperes
Max Signal Plate Input†				20	Kilowatts
Plate Dissipation†				5	Kilowatts
D-c Plate Voltage	6000	10000	12500		Volts
D-c Grid Voltage*	-600	-1100	-1450		Volts
Peak A-f Grid-to-grid Voltage	2200	3400	3960		Volts
Zero Signal D-c Plate Current	0.5	0.5	0.4		Amperes
Max Signal D-c Plate Current	2.3	3.2	2.8		Amperes
Load Resistance (per tube)	1250	1600	2500		Ohms

CLASS B A-F POWER AMPLIFIER AND MODULATOR (CONT'D)

	Typical Operation			Maximum Ratings	
Effective Load Resistance(plate-to-plate)	5000	6400	10000		Ohms
Max Signal Driving Power, approx	260	324	350		Watts
Max Signal Power Output, approx	8	20	22		Kilowatts

Unless otherwise specified, values are for two tubes.

CLASS B R-F POWER AMPLIFIER - TELEPHONY
Carrier conditions per tube for use with a maximum modulation factor of 1.0

D-c Plate Voltage				15000	Volts
D-c Plate Current				1.0	Amperes
Plate Input				10	Kilowatts
Plate Dissipation				6	Kilowatts
D-c Plate Voltage	6000	10000	14000		Volts
D-c Grid Voltage **	-600	-1130	-1600		Volts
Peak R-f Grid Voltage	600	830	1000		Volts
D-c Plate Current	0.7	0.8	0.56		Ampere
Driving Power, approx#	82	0	0		Watts
Power Output, approx	1	2	2.275		Kilowatts

CLASS C PLATE-MODULATED R-F POWER AMPLIFIER - TELEPHONY
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage			8000	Volts
D-c Grid Voltage			-3000	Volts
D-c Plate Current			1.0	Ampere
D-c Grid Current			0.15	Ampere
Plate Input			8	Kilowatts
Plate Dissipation			4	Kilowatts
D-c Plate Voltage	6000	8000		Volts
D-c Grid Voltage	-2000	-2400		Volts
Peak R-f Grid Voltage	2650	3100		Volts
D-c Plate Current	0.75	0.78		Ampere
D-c Grid Current, approx	0.1	0.08		Ampere
Driving Power, approx	260	260		Watts
Power Output, approx	3.5	5		Kilowatts

CLASS C R-F POWER AMPLIFIER - TELEGRAPHY
Key-down conditions per tube without modulation##

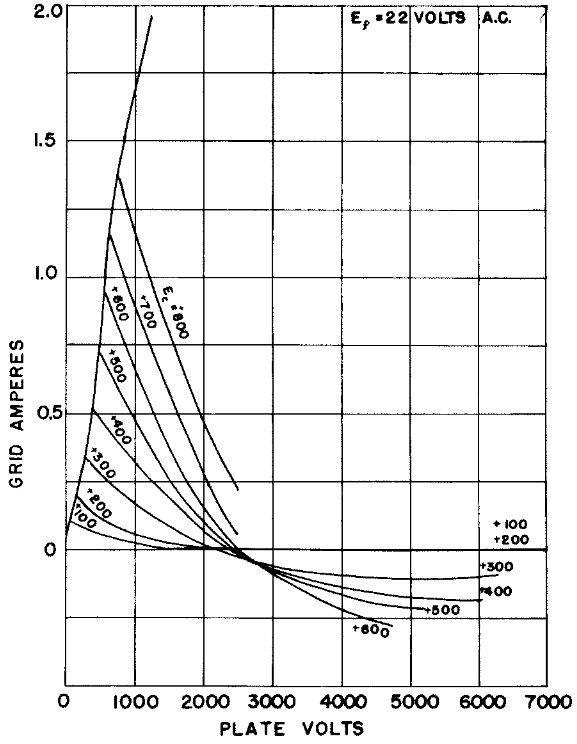
D-c Plate Voltage			12000	Volts
D-c Grid Voltage			-3000	Volts
D-c Plate Current			2.0	Amperes
D-c Grid Current			0.15	Ampere
Plate Input			18	Kilowatts
Plate Dissipation			6	Kilowatts
D-c Plate Voltage	8000	10000		Volts
D-c Grid Voltage	-1800	-2000		Volts
Peak R-f Grid Voltage	2500	2900		Volts
D-c Plate Current	1.1	1.45		Amperes
D-c Grid Current, approx	0.06	0.105		Ampere
Driving Power, approx	150	310		Watts
Power Output, approx	6.5	10		Kilowatts

† Averaged over any audio-frequency cycle.
* With a-c filament supply.
** With d-c filament supply.
\# At crest of a-f cycle with modulation factor of 1.0
\## Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

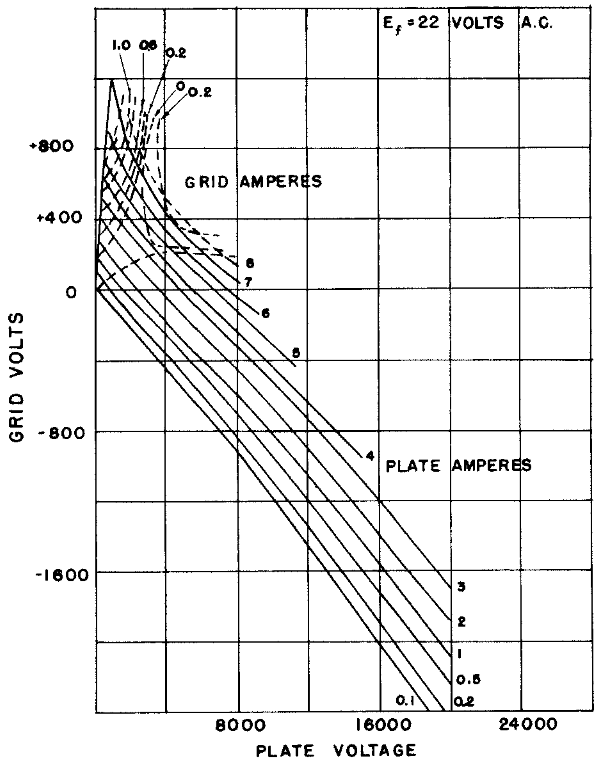
GL-891 can be operated at maximum ratings in all classes of service at frequencies as high as 1.6 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.) The tabulation shows the highest percentage of

maximum plate voltage and power input that can be used up to 20 mc for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

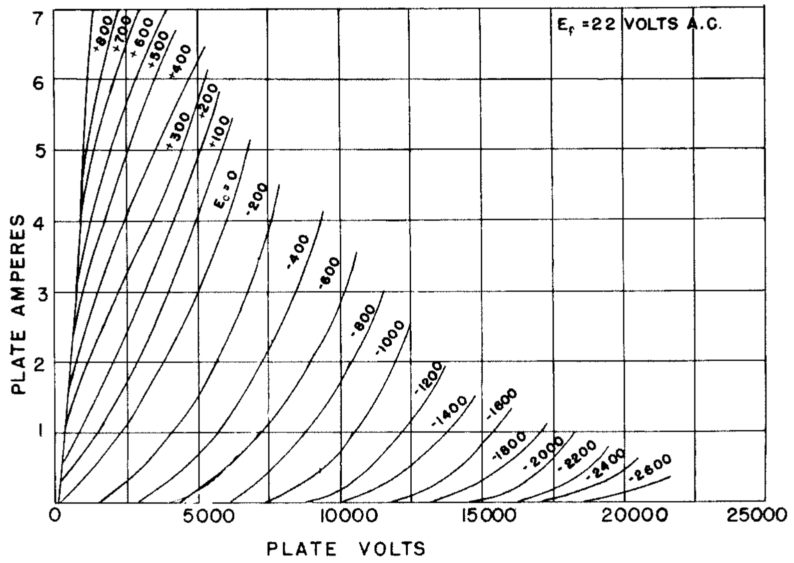
FREQUENCY	1.6	7.5	20	Mc
MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT:				
Class B telephony	100	82	72	Per cent
Class C (telephony, plate modulated	100	75	65	Per cent
(telegraphy	100	75	50	Per cent



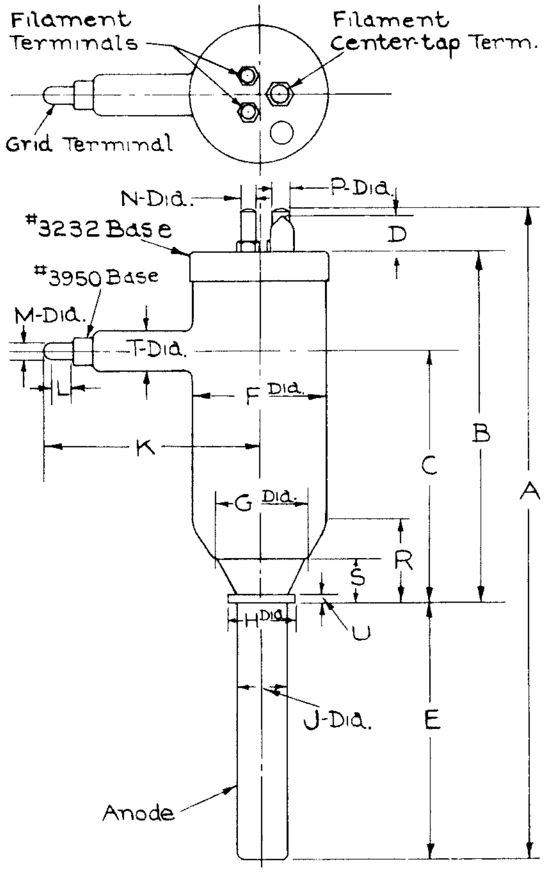
Grid-current Characteristics
for Transmitting Tube GL-891
K-8639621 3-15-44



Constant Current Plate
and Grid Characteristics
K-8639622 3-15-44



Average Plate Characteristics
K-8639620 3-15-44

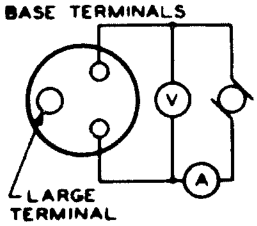


	Max.	Min.
A	20 5/8"	
B	11 1/16"	10 1/16"
C	7 15/16"	7 3/16"
D	1 1/8"	
E	8 3/16"	7 15/16"
F	4 1/16"	
G	2 7/16"	
H	2.015"	1.985"
J	1.625"	1.535"
K	6 1/2"	
L		.465"
M	.442"	.432"
N	.442"	432"
P	.505"	.495"
R		2 1/2"
S		1 7/16"
T	2"	
U	.197"	.177"

Outline Transmitting Tube GL-891
K-6966979 12-10-40

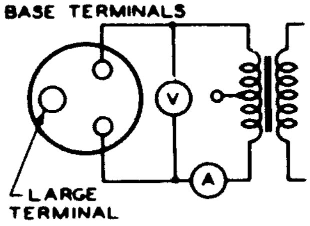
FILAMENT CONNECTIONS

WITH D-C EXCITATION



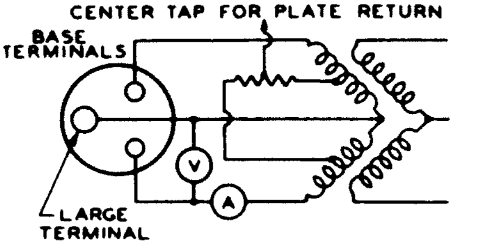
V = 22 VOLTS
A = 60 AMPERES

WITH SINGLE-PHASE A-C EXCITATION



V = 22 VOLTS
A = 60 AMPERES

WITH TWO-PHASE (QUARTER PHASE) A-C EXCITATION



V = 11 VOLTS
A = 60 AMPERES

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-891-R--Description and Rating

The 891-R is a three-electrode transmitting tube for use as a radio-frequency power amplifier, oscillator, Class A modulator and Class B modulator. The construction of the filament permits operation from two-phase or single-phase alternating current, as well as from direct current, for all classes of service. The plate of the 891-R is air-cooled by means of a special radiator which is fitted to the tube by the manufacturer. The plate is capable of dissipating 2 to 5 kilowatts of power, depending on the service in which the tube is used.

Technical Information

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Electrical

Filament	Two-unit Type
Voltage per unit	11 Volts
Current per unit	60 Amperes
Amplification Factor	8
Direct Interelectrode Capacitances, approx	
Grid-Plate	30 uuf
Grid-Filament	18 uuf
Plate-Filament	2 uuf
Frequency for Maximum Ratings	1.6 Megacycles

Mechanical

Cooling - Air flow of 450 cfm normal must be started before application of any voltages and continue for at least 10 minutes after removal of voltages. See table on Page 3.

Base Description - See Outline	
Mounting Position - Vertical	
Maximum Over-all Dimensions - See Outline	
Length	22 Inches
Diameter	4 1/16 Inches
Net Weight, approx	
Shipping Weight	
Installation and Operation	GEH-1122

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS A A-F POWER AMPLIFIER AND MODULATOR

	Typical Operation	Maximum Ratings	
D-c Plate Voltage	6000	10000	Volts
Plate Dissipation		3.5	Kilowatts
Radiator Temperature†	160	180	C
D-c Grid Voltage*	-560		Volts
Peak A-f Grid Voltage	660		Volts
D-c Plate Current	0.58		Amperes
Plate Resistance	2150		Ohms
Load Resistance	8600		Ohms
Undistorted Power Output	.925		Kilowatts

CLASS B A-F POWER AMPLIFIER AND MODULATOR

	Typical § Operation		Maximum Ratings	
D-c Plate Voltage	6000	8000	10000	Volts
Max Signal D-c Plate Current	2.3	2.1	2.0Δ	Amperes
Max Signal Plate InputΔ			10.5	Kilowatts
Plate DissipationΔ			3.5	Kilowatts
Radiator Temperature†	140	155	180	C
D-c Grid Voltage*	-600	-800		Volts
Peak A-f Grid-to-grid Voltage	2200	2400		Volts
Zero Signal D-c Plate Current	0.5	0.5		Amperes
Load Resistance, per tube	1250	1850		Ohms
Effective Load Resistance, plate-to plate	5000	7400		Ohms
Max Signal Driving Power, approx	260	100		Watts
Max Signal Power Output, approx	8	10		Kilowatts

§ Unless otherwise specified, values are for two tubes.

CLASS B R-F POWER AMPLIFIER-TELEPHONY
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	6000	8000	10000	Volts
D-c Plate Current	0.7	0.6	1.0	Amperes
Plate Input			5.5	Kilowatts
Plate Dissipation			3.5	Kilowatts
Radiator Temperature†	140	160	180	C
D-c Grid Voltage¶	-600	-820		Volts
Peak R-f Grid Voltage	600	700		Volts
Driving Power, approxπ	82	0		Watts
Power Output, approx	1	1.3		Kilowatts

CLASS C PLATE-MODULATED R-F POWER AMPLIFIER-TELEPHONY
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	6000	8500	Volts
D-c Grid Voltage	-2000	-3000	Volts
D-c Plate Current	0.75	1.0	Ampere
D-c Grid Current	0.1	0.15	Ampere
Plate Input		8	Kilowatts
Plate Dissipation		2.5	Kilowatts
Radiator Temperature†	90	180	C
Peak R-f Grid Voltage	2650		Volts
Driving Power, approx	260		Watts
Power Output, approx	3.5		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - TELEGRAPHY
Key-down conditions per tube without modulation‡

D-c Plate Voltage	8000	10000	10000	Volts
D-c Grid Voltage	-1800	-2000	-3000	Volts
D-c Plate Current	1.1	1.4	2.0	Amperes
D-c Grid Current	0.06	0.11	0.15	Ampere
Plate Input			15	Kilowatts
Plate Dissipation			4	Kilowatts
Peak R-f Grid Voltage	2500	2900		Volts
Radiator Temperature†	120	160	180	C
Driving Power, approx	150	310		Watts
Power Output, approx	6.5	10		Kilowatts

MAXIMUM PLATE DISSIPATION VS AIR FLOW RATE

Air Flow Rate, cfm:	400	450	500	600	700
Max Plate Dissipation, Watts:					
Class A	3250	3500	3750	4250	4650

MAXIMUM PLATE DISSIPATION VS AIR FLOW RATE (CONT'D)

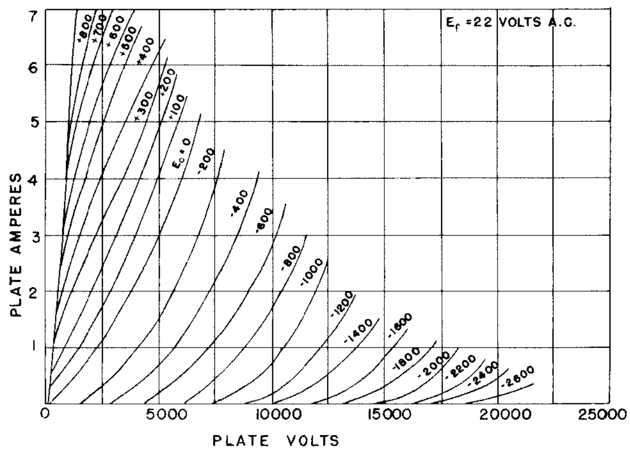
Max Plate Dissipation, Watts (Cont'd):

Class B, A-f	3250	3500	3750	4250	4650
Class B, R-f	3250	3500	3750	4250	4650
Class C, Telephony	2300	2500	2700	3000	3300
Class C, Telegraphy	3700	4000	4300	4850	5300

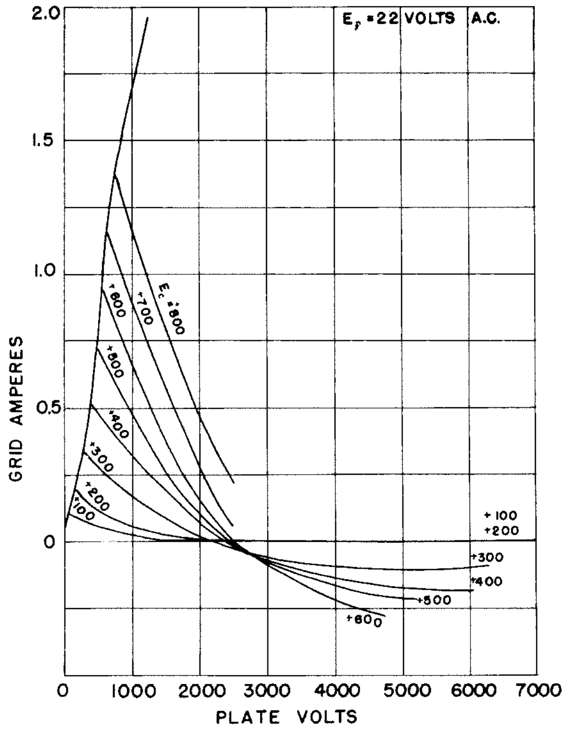
† Measured in thermometer well.
* With a-c filament supply.
Δ Averaged over any audio-frequency cycle of sine-wave form.
¶ With d-c filament supply.
π At crest of a-f cycle with modulation factor of 1.0
‡ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

GL-891-R can be operated at maximum ratings in all classes of service at frequencies as high as 1.6 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 10 mc for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

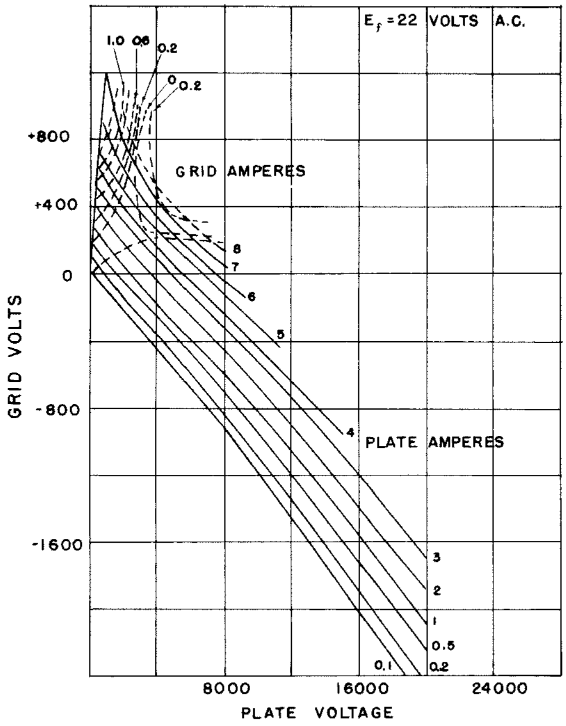
FREQUENCY	1.6	7.5	20	Mc
MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT:				
Class B telephony	100	83	74	Per Cent
Class C telephony, plate modulation) telegraphy)	100	75	50	Per Cent



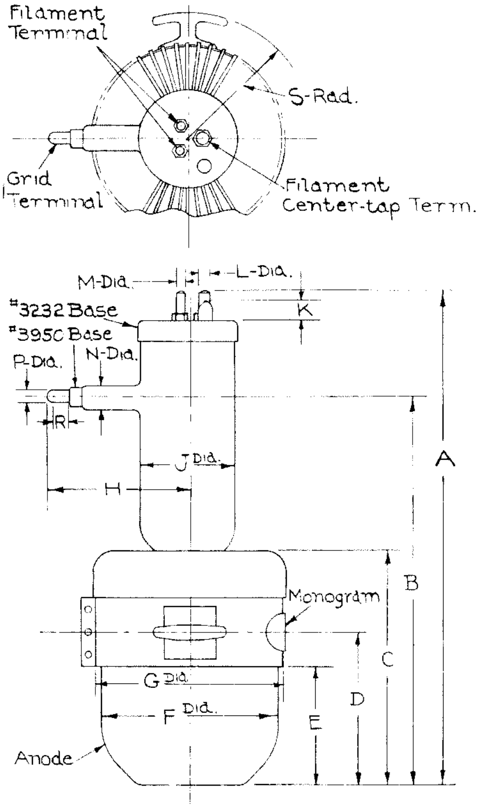
Average Plate Characteristics
for Transmitting Tube GL-891-R
K-8639620 3-15-44



Grid Current Characteristics
for Transmitting Tube GL-891-R
K-8639621 3-15-44



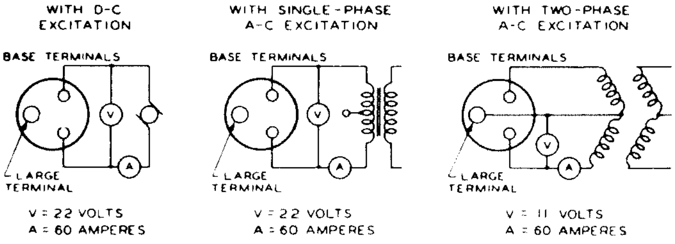
Constant Current Plate and Grid
Characteristics for Transmitting
Tube GL-891-R
K-8639622 3-15-44



	Max.	Min.
A	22"	
B	16 7/8"	16 1/8"
C	10 1/16"	9 15/16"
D	6 [illegible]/8	6 5/8"
E	5 5/16"	5 3/16"
F	7 9/16"	7 7/16"
G	8 1/32"	7 31/32"
H	6 1/2"	
J	4 1/16"	
K	1 1/8"	
L	.505"	.495"
M	.442"	.432"
N	2"	
P	.442"	.432"
R		.465"
S	5 7/16"	5 5/16"

Outline
GL-891-R Transmitting Tube
K-6966980 3-15-44

FILAMENT CONNECTIONS



GENERAL ELECTRIC

Transmitting Tube GL-892—Description and Rating

The 892 is a three-electrode transmitting tube of the double-filament type for use as a radio-frequency power amplifier, oscillator, and Class B modulator. The construction of the filament permits operation from two-phase or single-phase alternating current as well as from direct current, for all classes of service. The plate is water-cooled and is capable of dissipating 6.6 to 10 kilowatts, depending on the service in which the tube is used.

These data are for reference only. For design information, see the specifications.

Filament	Tungsten, Two-unit Type	
Excitation	1∅ A-c, 2∅ A-c or D-c	
Voltage, per unit	11	Volts
Current, per unit	60	Amp
Amplification Factor	50	
Direct Interelectrode Capacitances:		
Grid to Plate	27	μμf
Grid to Filament	18	μμf
Plate to Filament	2	μμf
Maximum Over-all Length		20-5/8 in.
Maximum Radius		6-1/2 in.
Cap		No. 3950
Base		No. 3232
Water Jacket		UT-1285A

Cooling - Water flow of 3 to 8 gallons per minute must start before application of any voltages and continue for at least 5 minutes after removal of voltages. Water temperature must not exceed 70 C under any conditions of operation.

MAXIMUM RATINGS AND TYPICAL OPERATION CONDITIONS

A-F POWER AMPLIFIER AND MODULATOR - CLASS B

D-c Plate Voltage	15000 max	Volts
Max-signal D-c Plate Current *	2.0 max	Amp
Max-signal Plate Input *	20 max	Kw
Plate Dissipation	7.5 max	Kw

Typical Operation:

Unless otherwise specified, values are for 2 tubes.

D-c Plate Voltage	6000	10000	12500	Volts
D-c Grid Voltage †	0	-90	-170	Volts
Peak A-f Grid-to-Grid Voltage	1200	1620	1530	Volts
Zero-signal D-c Plate Current	0.5	0.5	0.4	Amp
Max-signal D-c Plate Current	2.5	3.2	2.8	Amp
Load Resistance (per tube)	1050	1600	2500	Ohms
Effective Load Resistance (plate-to-plate)	4200	6400	10000	Ohms
Max-signal Driving Power	415	525	420	Approx watts
Max-signal Power Output	8	20	22	Approx kw

R-F POWER AMPLIFIER - CLASS B TELEPHONY

Carrier conditions per tube for use with a maximum modulation factor of 1.0

D-c Plate Voltage	15000 max	Volts
D-c Plate Current	1.0 max	Amp
R-f Grid Current	24 max	Amp

Plate Input			15 max	Kw
Plate Dissipation			10 max	Kw

Typical Operation:

Filament Voltage - See Filament Connections under Type 891.				
D-c Plate Voltage	6000	10000	14000	Volts
D-c Grid Voltage †	0	-100	-190	Volts
Peak R-f Grid Voltage	300	470	510	Volts
D-c Plate Current	0.67	0.93	0.95	Amp
Driving Power °	65	50	30	Approx watts
Power Output	1	2.5	4	Approx kw

PLATE-MODULATED R-F POWER AMPLIFIER - CLASS C TELEPHONY
Carrier conditions per tube for use with a maximum modulation factor of 1.0

D-c Plate Voltage	10000 max	Volts
D-c Grid Voltage	-3000 max	Volts
D-c Plate Current	1.0 max	Amp
D-c Grid Current	0.25 max	Amp
R-f Grid Current	24 max	Amp
Plate Input	10 max	Kw
Plate Dissipation	6.6 max	Kw

Typical Operation:

Filament Voltage - See Filament Connections under Type 891.				
D-c Plate Voltage	6000	8000	10000	Volts
D-c Grid Voltage	-1000	-1300	-1600	Volts
Peak R-f Grid Voltage	1675	2000	2400	Volts
D-c Plate Current	0.77	0.75	0.72	Amp
D-c Grid Current	0.185	0.175	0.115	Approx amp
Driving Power	310	350	260	Approx watts
Power Output	3.5	5	6	Approx kw

R-F POWER AMPLIFIER AND OSCILLATOR - CLASS C TELEGRAPHY
Key-down conditions per tube without modulation ††

D-c Plate Voltage	15000 max	Volts
D-c Grid Voltage	-3000 max	Volts
D-c Plate Current	2.0 max	Amp
D-c Grid Current	0.25 max	Amp
R-f Grid Current	30 max	Amp
Plate Input	30 max	Kw
Plate Dissipation	10 max	Kw

Typical Operation:

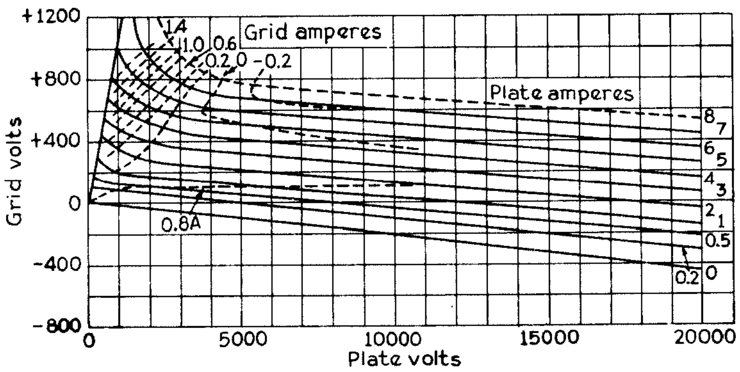
Filament Voltage - See Filament Connections under Type 891.				
D-c Plate Voltage	8000	10000	12000	Volts
D-c Grid Voltage	-1000	-1300	-1600	Volts
Peak R-f Grid Voltage	1800	2300	2800	Volts
D-c Plate Current	1.1	1.4	1.64	Amp
D-c Grid Current	0.18	0.18	0.18	Approx amp
Driving Power	320	400	500	Approx watts
Power Output	6.5	10	14	Approx kw

* Averaged over any audio-frequency cycle of sine-wave form.
† With d-c filament supply.
° At crest of a-f cycle with modulation factor of 1.0.
†† Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

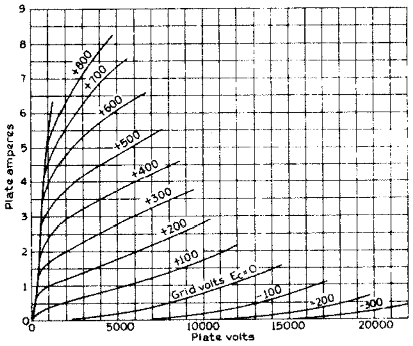
GL-892 can be operated at maximum ratings in all classes of service at frequencies as high as 1.6 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown under MAXIMUM RATING).

The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 20 mc for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

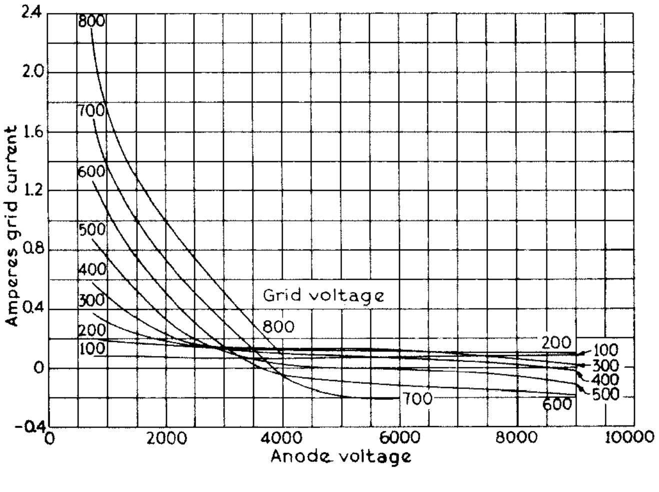
FREQUENCY	1.6	7.5	20	Mc
MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT:				
Class B telephony	100	82	72	Per Cent
Class C Plate-modulated	100	75	65	Per Cent
Unmodulated	100	75	50	Per Cent



Constant Current Plate and Grid Characteristics for Transmitting Tube GL-892
K-7000138 9-29-39

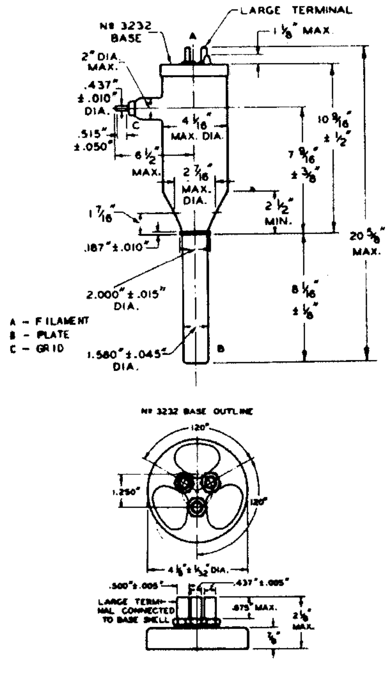


Average Plate Characteristics for Transmitting Tube GL-892
K-7000137 9-29-39



Grid-current Characteristics for Transmitting Tube GL-892
K-7000142 10-24-39

OUTLINE DRAWING



ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-892-R--Description and Rating

The 892-R is a three-electrode transmitting tube for use as a radio-frequency power amplifier, oscillator, and Class B modulator. The construction of the filament permits operation from two-phase or single-phase alternating current, as well as from direct current, for all classes of service. The plate of the 892-R is air-cooled by means of a special radiator which is fitted to the tube by the manufacturer. The plate is capable of dissipating 2 to 5 kilowatts of power, depending on the service in which the tube is used.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Electrical

	Two-unit Type	
Filament		
Voltage per unit	11	Volts
Current per unit	60	Amperes
Amplification Factor	50	
Direct Interelectrode Capacitances, approx		
Grid - Plate	30	uuf
Grid - Filament	18	uuf
Plate - Filament	2	uuf

Mechanical

Cooling - Air flow of 450 cfm normal must be started before application of any voltages and continue for at least 10 minutes after removal of voltages. See table on page 2.

Base Description - See Outline

Mounting Position - Vertical

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B A-F POWER AMPLIFIER AND MODULATOR

	Typical Operation		Maximum Ratings	
D-c Plate Voltage	6000	8000	12500	Volts
Max Signal D-c Plate Current◊	2.5	2.3	2.0	Amperes
Max Signal Plate Input◊			12	Kilowatts
Plate Dissipation◊			4	Kilowatts
Radiator Temperature*			180 C	
D-c Grid Voltage†	0	-60		Volts
Peak A-f Grid-to-grid Voltage	1200	1000		Volts
Zero Signal D-c Plate Current	0.5	0.5		Amperes
Radiator Temperature*	140 C	158 C		
Load Resistance (per tube)	1050	1700		Ohms
Effective Load Resistance (plate-to-plate)	4200	6800		Ohms
Max Signal Driving Power, approx	415	400		Watts
Max Signal Power Output, approx	8	10.5		Kilowatts

Unless otherwise specified, values are for two tubes.

CLASS B R-F AMPLIFIER - TELEPHONY
Carrier conditions per tube for use with a max modulation factor of 1.0

	Typical Operation		Maximum Ratings	
D-c Plate Voltage	6000	8000	12500	Volts
D-c Plate Current	0.67	0.71	1.0	Amperes
Plate Input			6	Kilowatts
Plate Dissipation			4	Kilowatts
Radiator Temperature*	140 C	160 C	180 C	
D-c Grid Voltage‡	0	-40		Volts
Peak R-f Grid Voltage△	300	350		Volts
Driving Power, approx△	65	25		Watts
Power Output, approx	1	1.7		Kilowatts

CLASS C PLATE-MODULATED R-F POWER AMPLIFIER - TELEPHONY
Carrier conditions per tube for use with max modulation factor of 1.0

D-c Plate Voltage	6000	8000	10000	Volts
D-c Grid Voltage	-1000	-1300	-3000	Volts
D-c Plate Current	0.77	0.75	1.0	Amperes
D-c Grid Current			0.25	Ampere
Plate Input			10	Kilowatts
Plate Dissipation			2.5	Kilowatts
Radiator Temperature* •	90 C	90 C	180 C	
Peak R-f Grid Voltage	1675	2000		Volts
D-c Grid Current, approx	0.19	0.18		Ampere
Driving Power, approx	310	350		Watts
Power Output, approx	3.5	5		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - TELEGRAPHY
Key-down conditions per tube without modulation§

D-c Plate Voltage	8000	10000	12500	Volts
D-c Grid Voltage	-1000	-1300	-3000	Volts
D-c Plate Current	1.1	1.4	2.0	Amperes
D-c Grid Current			0.25	Ampere
Plate Input			18	Kilowatts
Plate Dissipation			4	Kilowatts
Radiator Temperature*	120 C	160 C	180 C	
Peak R-f Grid Voltage	1800	2300		Volts
D-c Grid Current, approx	0.18	0.18		Ampere
Driving Power, approx	320	400		Watts
Power Output, approx	6.5	10		Kilowatts

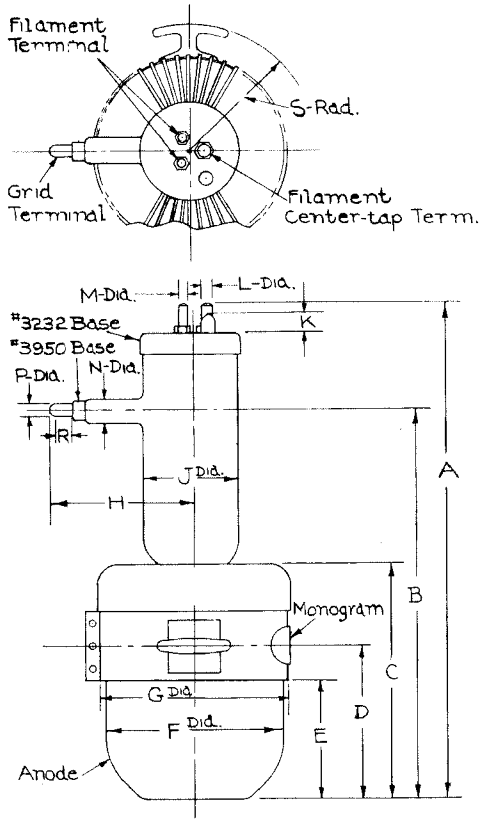
MAXIMUM PLATE DISSIPATION VS AIR FLOW RATE

Air Flow Rate, cfm:	400	450	500	600	700
Max Plate Dissipation, Watts:					
Class B, A-f	3700	4000	4300	4850	5300
Class B, R-f	3700	4000	4300	4850	5300
Class C, Telephony	2300	2500	2700	3000	3300
Class C, Telegraphy	3700	4000	4300	4850	5300

◊ Averaged over any audio-frequency cycle.
† With a-c filament excitation.
* Measured in thermometer well.
‡ With d-c filament excitation.
△ At crest of A-f cycle with modulation factor of 1.0.
§ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier condition.

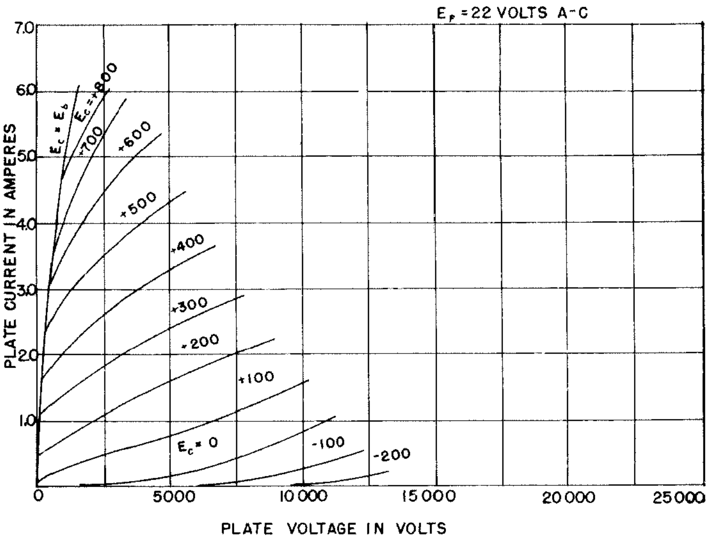
GL-892-R can be operated at maximum ratings in all classes of service at frequencies as high as 1.6 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 10 mc for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

FREQUENCY	1.6	7.5	20	Mc
MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT:				
Class B telephony	100	85	76	Per cent
Class C (telephony, plate modulated (telegraphy	100	75	50	Per cent

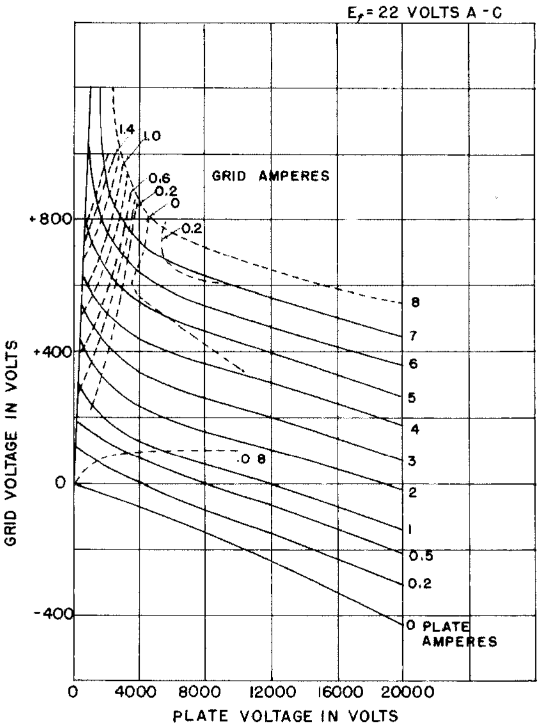


	Max.	Min.
A	22"	
B	16 7/8"	16 1/8"
C	10 1/16"	9 15/16"
D	6 [illegible]/8"	6 5/8"
E	5 5/16"	5 3/16"
F	7 9/16"	7 7/16"
G	8 1/32"	7 31/32"
H	6 1/2"	
J	4 1/16"	
K	1 1/8"	
L	.505"	.495"
M	.442"	.432"
N	2"	
P	.442"	.432"
R		.465"
S	5 7/16"	5 5/16"

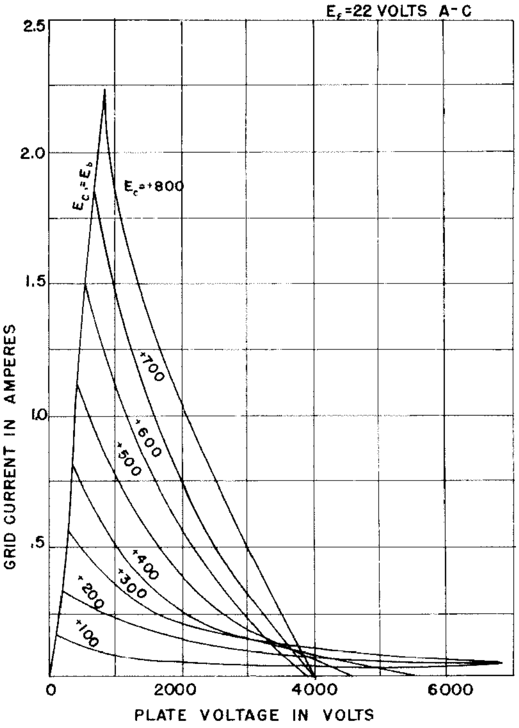
Outline Transmitting Tube GL-892-R
K-6966980 11-13-41



Average Plate Characteristics
for Transmitting Tube GL-892-R
K-8639397 3-25-44



Constant Current Plate and Grid
Characteristics for Transmitting Tube
GL-892-R
K-8639395 3-25-44



Grid-current Characteristics
for Transmitting Tube GL-892-R
K-8639396 3-25-44

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

5-44 (7M)
Filing No. 8850

Superseding GET-915

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-893-A--Description and Rating

The GL-893-A is a three-electrode, water-cooled vacuum tube designed for use as a radio-frequency amplifier, oscillator, or Class B modulator. A particular advantage of this tube is the unique construction of the filament which permits operation from single-phase, three-phase, or six-phase alternating current, or from direct current, for all classes of service.

TECHNICAL INFORMATION

CHARACTERISTICS AND RATINGS

ELECTRICAL

Filament Voltage, per strand		10	Volts
Filament Current, per terminal		61	Amperes
Amplification Factor	E_b = 15 kv, I_b = 1.0 amp	36	
Grid-plate Transconductance	E_c = -300, E_f = 20 a-c	16000	Micromhos
Direct Interelectrode Capacitances:			
Grid-plate		33	μμf
Input		48	μμf
Output		3.2	μμf
Frequency for Maximum Ratings		5	Megacycles

MECHANICAL

Gasket, Cat. No. 5182028P2	
Type of Cooling	Water and Forced Air
Water Flow, gallons per minute	8-15
Air Flow, cubic feet per minute	
To Stem	2
Net Weight, approx	12 lb
Shipping Weight, approx	27 lb
Installation and Operation	ET-H1

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B A-F POWER AMPLIFIER (TWO TUBES)

D-c Plate Voltage	12000	15000	18000	20000 max	Volts
Max Signal Plate Current, per tube*				4.0 max	Amperes
D-c Max Signal Plate Input, per tube*				60 max	Kilowatts
Plate Dissipation, per tube*				20 max	Kilowatts
D-c Grid Voltage	-260	-350	-450		Volts
Peak A-f Grid Input Voltage	1480	1560	1720		Volts
Zero Signal Plate Current	0.8	0.8	0.8		Ampere
Max Signal Plate Current	7.0	6.0	5.5		Amperes
Max Signal Plate Input*	84.0	90.0	99.0		Kilowatts
Max Signal Driving Power, approx	220	190	140		Watts
Effective Load Resistance, Plate-to-plate	4000	6000	8000		Ohms
Max Signal Plate Power Output	52.0	60.0	70.0		Kilowatts

CLASS B R-F POWER AMPLIFIER

Carrier conditions per tube for use with a max modulation factor 1.0

D-c Plate Voltage	12000	15000	15000	20000 max	Volts
D-c Grid Voltage	-250	-340	-340		Volts
D-c Plate Current	1.5	1.5	2.0	2.0 max	Amperes
Plate Input				32 max	Kilowatts
Plate Dissipation				20 max	Kilowatts
Peak R-f Grid Input Voltage	700	790	900		Volts
Driving Power, approx **	130	150	200		Watts
Plate Power Output	6	7.5	10		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE-MODULATED
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	10000	10000	12000	12000 max	Volts
D-c Grid Voltage	-800	-800	-1000	-3000 max	Volts
D-c Plate Current	1.5	2.0	2.0	2.0 max	Amperes
D-c Grid Current, approx	0.10	0.16	0.14	0.4 max	Amperes
Plate Input				24 max	Kilowatts
Plate Dissipation				12	Kilowatts
Peak R-f Grid Input Voltage, approx	1200	1280	1500		Volts
Driving Power, approx	120	210	210		Watts
Plate Power Output	11	15	18		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
Key-down conditions per tube without modulation

D-c Plate Voltage	12000	15000	18000	20000 max	Volts
D-c Grid Voltage	-800	-900	-1000	-3000 max	Volts
D-c Plate Current	3.5	3.6	3.6	4.0 max	Amperes
D-c Grid Current, approx	0.26	0.25	0.21	0.4 max	Amperes
Plate Input				70 max	Kilowatts
Plate Dissipation				20 max	Kilowatts
Peak R-f Grid Input Voltage,approx	1430	1520	1630		Volts
Driving Power, approx	360	370	340		Watts
Plate Power Output	30	40	50		Kilowatts

* Averaged over any audio-frequency cycle.
** At crest of audio-frequency cycle.
\# Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

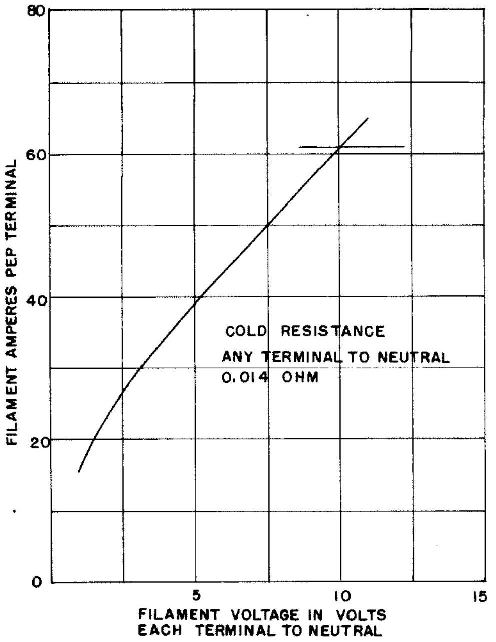
GL-893 can be operated at maximum ratings in all classes of service at frequencies as high as 5 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (Other maximum ratings are the same as shown under CHARACTERISTICS and RATINGS.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 40 mc for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

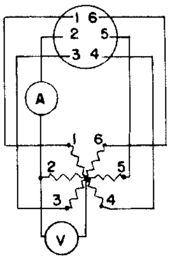
FREQUENCY	5	20	40	Mc
MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT:				
Class B R-f				
Percentage Plate Voltage	100	85	65	
Percentage Plate Input	100	82	73	
Class C Plate Modulated				
Percentage Plate Voltage	100	80	64	
Percentage Plate Input	100	75	64	
Class C				
Percentage Plate Voltage	100	80	60	
Percentage Plate Input	100	66	50	

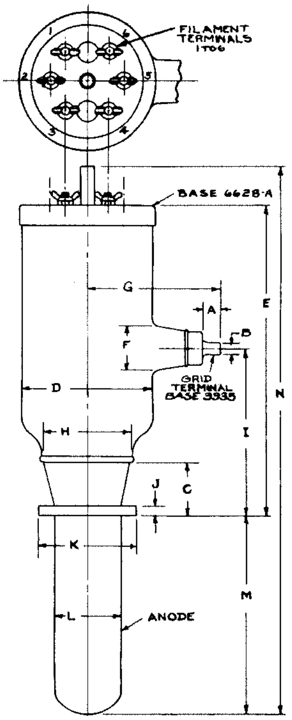
APPLICATION NOTES

Plate Series Protective Resistors (see paragraph describing plate circuit under Installation in the Instructions).

Series Resistor, ohms	10	20	40	80	100
Maximum Power Output of Rectifier, kilowatts	40	100	250	640	1600





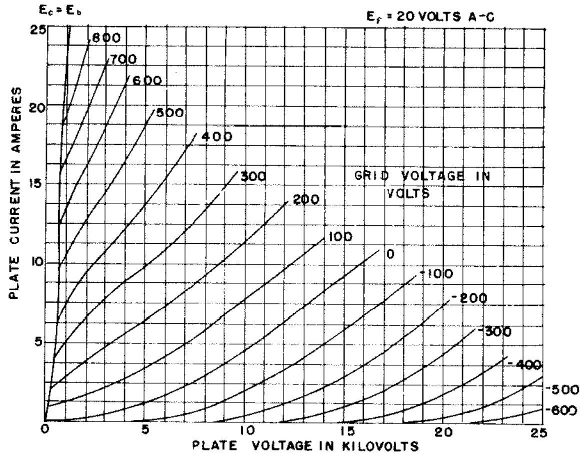


DIMENSIONS IN INCHES	MIN.	MAX.
● A	.687	.812
B	.561	.571
C	2.000	2.750
D	5.870	6.130
E	14.000	15.000
F	1.500	3.060
G	5.625	6.375
H	3.810	4.060
I	7.375	8.125
J	.480	.520
K	4.672	4.702
L	3.125	3.250
M	9.000	9.500
N	24.500	26.750

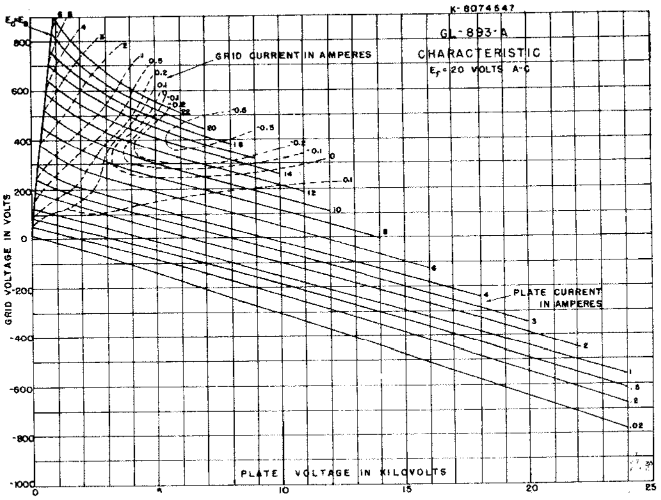
● AVAILABLE STRAIGHT SIDE 0.500" MIN.

Average Filament Characteristic
K-8074643 5-5-44

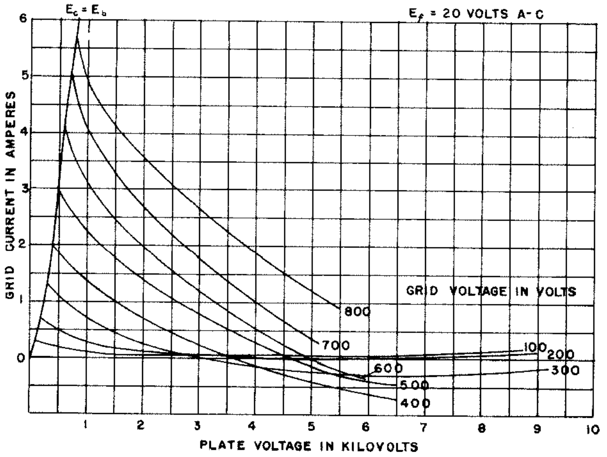
Outline Transmitting Tube
GL-893-A
K-5344783 2-11-42



Average Plate Characteristics for Transmitting Tube GL-893-A
K-8074645 5-5-44

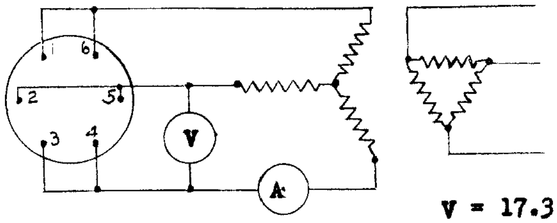


Characteristics for Transmitting Tube GL-893-A
K-8074647 5-5-44



Typical Grid-plate Transfer Characteristics for Transmitting Tube GL-893-A
K-8074644 5-5-44

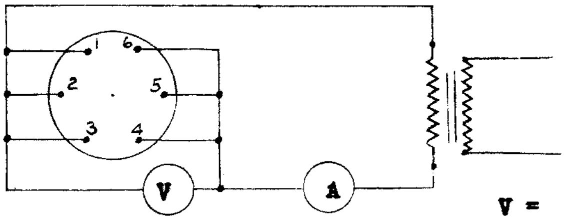
Filament Base Terminals



V = 17.3 volts
A = 122 amps.

Three-phase A-c Filament Excitation

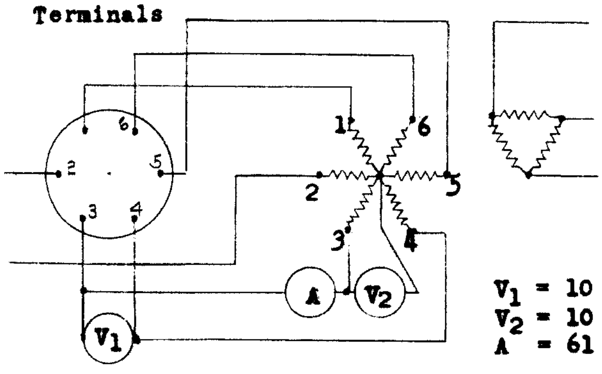
Filament Base Terminals



V = 20 volts
A = 183 amps.

Single-phase A-c Filament Excitation

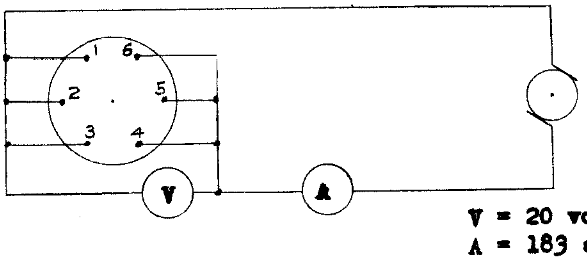
Filament Base Terminals



V_1 = 10 volts
V_2 = 10 volts
A = 61 amps.

Six-phase A-c Filament Excitation

Filament Base Terminals



V = 20 volts
A = 183 amps.

D-c Filament Excitation

NOTE: Terminals must be connected in correct phase relation as shown
K-7050604 Filament Connections and Excitation Circuits 5-29-39

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

5-44 (8000)
Filing No. 8850

Supersedes GET-766A

GENERAL ELECTRIC

Transmitting Tube GL-893-R -- Description and Rating

Description

The GL-893-R is a three-electrode, forced air-cooled vacuum tube designed for use as a radio-frequency amplifier, oscillator, or Class B modulator. A particular advantage of this tube is the unique construction of the filament which permits operation from single-phase, three-phase, or six-phase alternating current, or from direct current, for all classes of service.

Technical Information

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

ELECTRICAL		
Filament Voltage (per strand)	10	Volts
Filament Current (per terminal)	61	Amperes
Amplification Factor, E_b = 15 kv, I_b = 1.0 amp, E_c = -300, E_f = 20 a-c	36	
Grid-plate Transconductance	16000	Micromhos
Direct Interelectrode Capacitances, μμf		
Grid-plate	33	
Grid-filament	48	
Plate-filament	3.2	
MECHANICAL		
Type of Cooling	Forced Air	
Air Flow		
To radiator	1800	Cu ft per minute
To stem	2	Cu ft per minute
Net Weight (approx)	230	Pounds
Shipping Weight (approx)	290	Pounds
Installation and Operation	GEH-1198	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

	Typical Operation			Maximum* Ratings	
CLASS B A-F POWER AMPLIFIER (TWO TUBES)					
D-c Plate Voltage	12000	15000	18000	20000	Volts
Max Signal Plate Current (per tube)†				4.0	Amperes
D-c Max Signal Plate Input (per tube)†				60	Kilowatts
Plate Dissipation (per tube)†				20	Kilowatts
Radiator Temperature‡				180	C
D-c Grid Voltage	-260	-350	-450		Volts
Peak A-f Grid Input Voltage	1480	1560	1720		Volts
Zero Signal Plate Current	0.8	0.8	0.8		Amperes
Max Signal Plate Current	7.0	6.0	5.5		Amperes
Max Signal Plate Input†	84	90	99		Kilowatts
Max Signal Driving Power (approx)	220	190	140		Watts
Effective Load Resistance (plate-to-plate)	4000	6000	8000		Ohms
Max Signal Plate Power Output	52	60	70		Kilowatts
CLASS B R-F POWER AMPLIFIER					
Carrier conditions per tube for use with a max modulation factor of 1.0					
D-c Plate Voltage	12000	15000	15000	20000	Volts
D-c Grid Voltage	-250	-340	-340		Volts
D-c Plate Current	1.5	1.5	2.0	2.0	Amperes

	Typical Operation			Maximum* Ratings	
Plate Input				32	Kilowatts
Plate Dissipation				20	Kilowatts
Radiator Temperature‡				180	C
Peak R-f Grid Input Voltage§	700	790	900		Volts
Driving Power (approx)§	130	150	200		Watts
Plate Power Output	6	7.5	10		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE-MODULATED
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	10000	10000	12000	12000	Volts
D-c Grid Voltage	-800	-800	-1000	-3000	Volts
D-c Plate Current	1.5	2.0	2.0	2.0	Amperes
D-c Grid Current (approx)	0.10	0.16	0.14	0.4	Ampere
Plate Input				24	Kilowatts
Plate Dissipation				12	Kilowatts
Radiator Temperature‡ (Modulation Factor = 1.0)				180	C
Peak R-f Grid Input Voltage (approx)	1200	1280	1500		Volts
Driving Power (approx)	120	210	210		Watts
Plate Power Output	11	15	18		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
Key-down conditions per tube without modulation¶

D-c Plate Voltage	12000	15000	18000	20000	Volts
D-c Grid Voltage	-800	-900	-1000	-3000	Volts
D-c Plate Current	3.5	3.6	3.6	4.0	Amperes
D-c Grid Current (approx)	0.26	0.25	0.21	0.4	Ampere
Plate Input				70	Kilowatts
Plate Dissipation				20	Kilowatts
Radiator Temperature‡				180	C
Peak R-f Grid Input Voltage (approx)	1430	1520	1630		Volts
Driving Power (approx)	360	370	340		Watts
Plate Power Output	30	40	50		Kilowatts

† Averaged over any audio-frequency cycle.

‡ Measured in the thermometer well. This temperature corresponds to the maximum ratings when the air-flow is 1800 cubic feet per minute and the temperature of the incoming air does not exceed 45 C. The glass temperature must not be allowed to exceed 150 C.

§ At crest of audio-frequency cycle.

¶ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

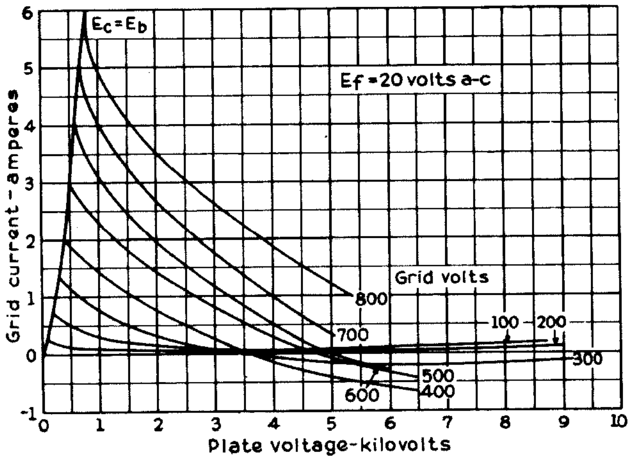
APPLICATION NOTES

* The GL-893-R can be operated at frequencies as high as 5 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 25 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

Frequency - Mc	5	12	25
Class B R-f			
Per Cent Max Plate Voltage and Plate Input	100	86	74
Class C Plate-modulated			
Per Cent Max Plate Voltage and Plate Input	100	81	65
Class C			
Per Cent Max Plate Voltage	100	81	65
Per Cent Max Plate Input	100	75	50

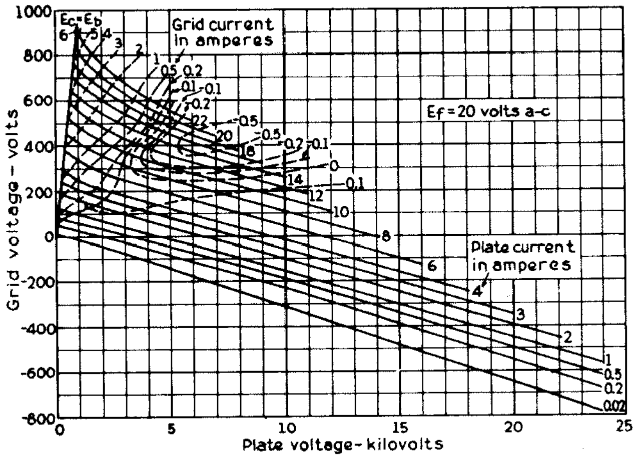
Plate Series Protective Resistors (see paragraph describing plate circuit under Installation in the Instructions).

Series Resistor, ohms	10	20	40	80	100
Maximum Power Output of Rectifier, kw	40	100	250	640	1600



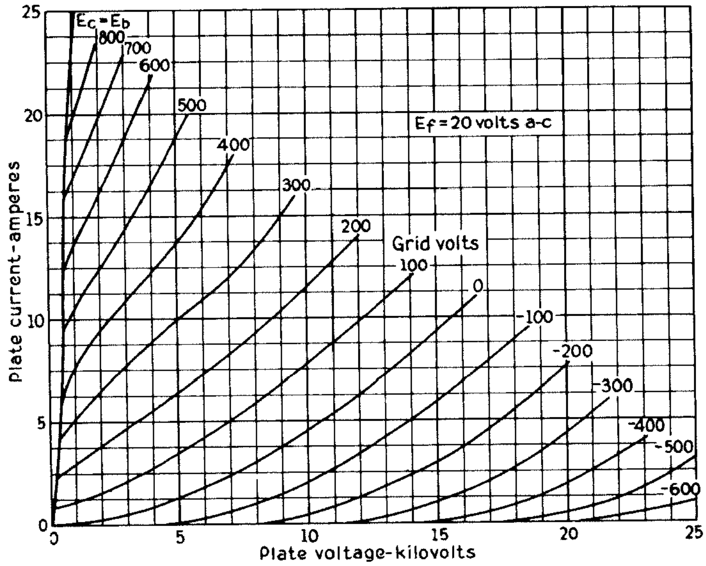
Typical Grid-plate Transfer Characteristics for Transmitting Tube GL-893-R

K-7050618 5-22-39



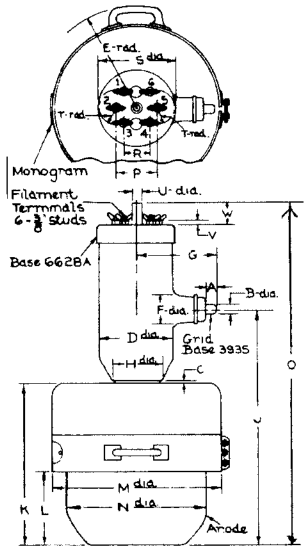
Characteristics for Transmitting Tube GL-893-R

K-7050611 5-22-39



Average Plate Characteristics for Transmitting Tube GL-893-R

K-7050615 5-22-39

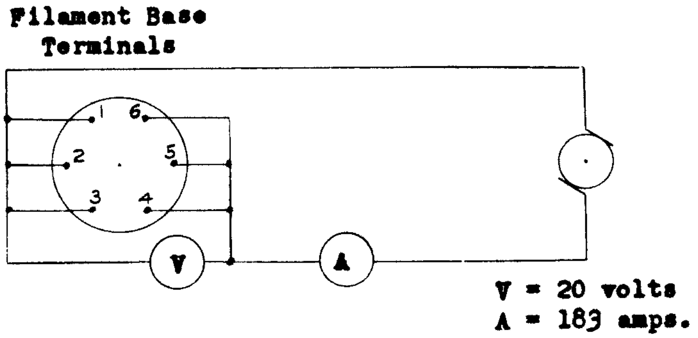


	Max.	Min.
A	.812"	.687"
B	.571"	.561"
C	[illegible]	
D	6.130"	5.870
E	8 [illegible]	8 1/16"
F	3 [illegible]	1 [illegible]
G	6 [illegible]	5 [illegible]
H	4 1/16"	3 [illegible]
J	18 [illegible]	17 [illegible]
K	12 [illegible]	12 [illegible]
L	6 [illegible]	5 [illegible]
M	14 [illegible]	13 [illegible]
N	11 [illegible]	11 [illegible]
O	28"	25 [illegible]
P	3.410"	3.340
R	2.035	1.965"
S	6 [illegible]	6 [illegible]
T	1.535"	1.465"
U	.660"	.590"
V	.285"	.215"
W	2 [illegible]	1 [illegible]

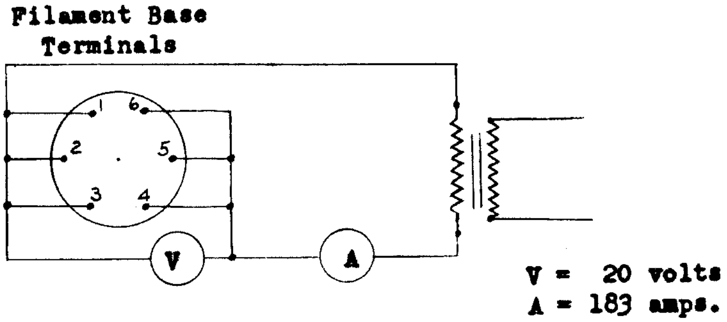
Outline Transmitting Tube GL-893-R

K-6966982 12-26-40

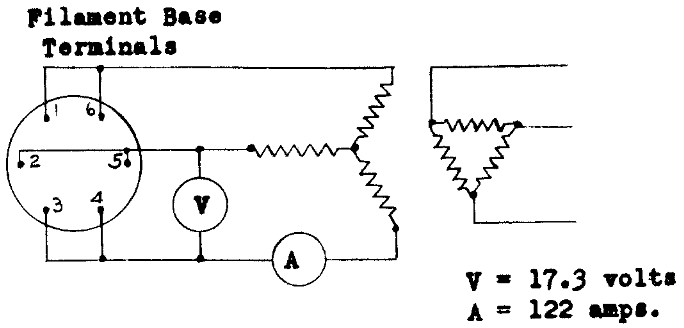
D-C Filament Excitation



Single-Phase A-C Filament Excitation

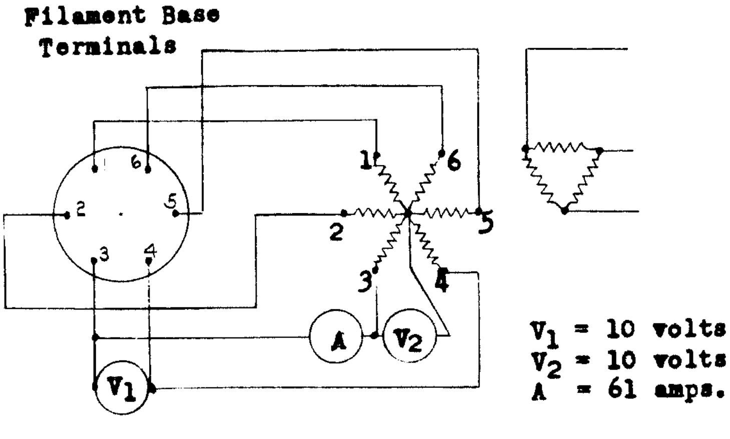


Three-Phase A-C Filament Excitation



Six-Phase A-C Filament Excitation

NOTE: Terminals must be connected in correct phase relation as shown



Filament Connections and Excitation Circuits
K-7050604 5-22-39

GENERAL ELECTRIC COMPANY
SCHENECTADY, N. Y.

Supersedes GET-959

1-42 (2500)
Filing No. 8850

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-898A--Description and Rating

The 898A is a three-electrode power tube designed for use as a radio-frequency amplifier, oscillator, or Class B modulator. The filament consists of three sections and can be operated on d-c, single-phase, or three-phase filament excitation.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Number of Electrodes	3

Electrical

Cathode - Filamentary	
Filament Voltage, per section	33 Volts
Filament Current, per section	70 Amperes
Average Characteristics, Eb = 20.5 kv Ib = 3.0 amperes, E_f = 33 volts	
Grid Voltage	-100 Volts
Amplification Factor	45
Grid-plate Transconductance, I_b = 3.0 amperes	17500 Micromhos
Direct Interelectrode Capacitances	
Grid-plate	62 Micromicrofarad
Grid-filament	52 Micromicrofarad
Plate-filament	4.2 Micromicrofarad
Frequency for Maximum Ratings	1.6 Megacycles

Mechanical

Type of Cooling - Water and Forced-air
Maximum Outlet Temperature 70 C
Water Flow - 15 - 25 gallons per minute
Jacket Type - 7651927
Maximum Incoming Air Temperature 50 C
Flow - 15 Cubic feet per minute to bulb
3 Cubic feet per minute to stem

Gasket - Cat. No. 5182028 P1

Net Weight, approximate	30 Pounds
Shipping Weight, approximate	175 Pounds
Installation and Operation - ET-H1	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

	Typical Operation	Maximum Ratings	
CLASS B A-F POWER AMPLIFIER (TWO TUBES)			
D-c Plate Voltage	12000	15000	Volts
Maximum Signal Plate Currentt, per tube		7.5	Amperes
D-c Maximum Signal Plate Inputt, per tube		100	Kilowatts

	Typical Operation			Maximum Ratings	
Plate Dissipation†, per tube				50	Kilowatts
D-c Grid Voltage			-100		Volts
Peak A-f Grid Input Voltage			2200		Volts
Zero Signal Plate Current			2		Amperes
Maximum Signal Plate Current			13		Amperes
Maximum Signal Driving Power, approximate			6		Kilowatts
Effective Load, plate-to-plate			2000		Ohms
Maximum Signal Plate Power Output, approximate			90		Kilowatts

CLASS B R-F POWER AMPLIFIER
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage	12000	15000	18000	20000	Volts
D-c Grid Voltage	-100	-175	-250		Volts
D-c Plate Current	218	3.5	4.2	5	Amperes
Plate Input				100	Kilowatts
Plate Dissipation				75	Kilowatts
Peak R-f Grid Input Voltage	525	650	775		Volts
Driving Power‡, approximate	0.5	0.75	1.1		Kilowatts
Plate Power Output, approximate	11	17.5	25		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED
Carrier conditions per tube for use with a max modulation factor of 1.0

D-c Plate Voltage			12000	12000	Volts
D-c Grid Voltage			-800	-3000	Volts
D-c Plate Current			5	5	Amperes
D-c Grid Current, approximate			1	1.25	Amperes
Plate Input				60	Kilowatts
Plate Dissipation				50	Kilowatts
Peak R-f Grid Input Voltage			2000		Volts
Driving Power			2		Kilowatts
Plate Power Output			45		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
Key-down conditions per tube without modulation§

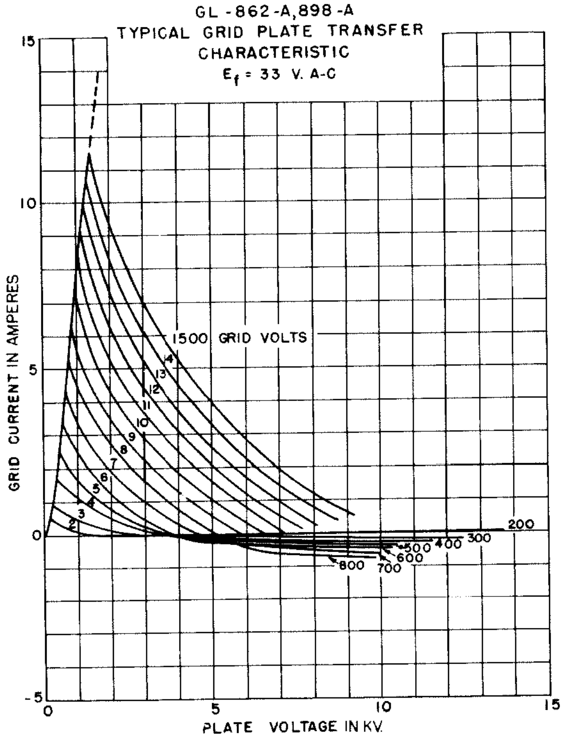
D-c Plate Voltage	12000	15000	18000	20000	Volts
D-c Grid Voltage	-800	-900	-1000	-3000	Volts
D-c Plate Current	6.25	7.5	8.33	10	Amperes
D-c Grid Current, approximate	0.8	0.85	0.9	1	Ampere
Plate Input				200	Kilowatts
Plate Dissipation				100	Kilowatts
Peak R-f Grid Input Voltage, approximate	2050	2300	2550		Volts
Driving Power, approximate	1.6	2	2.4		Kilowatts
Plate Power Output, approximate	50	75	100		Kilowatts

APPLICATION NOTES

Plate Series Protective Resistors (see paragraph describing plate circuit under Installation in the Instructions)

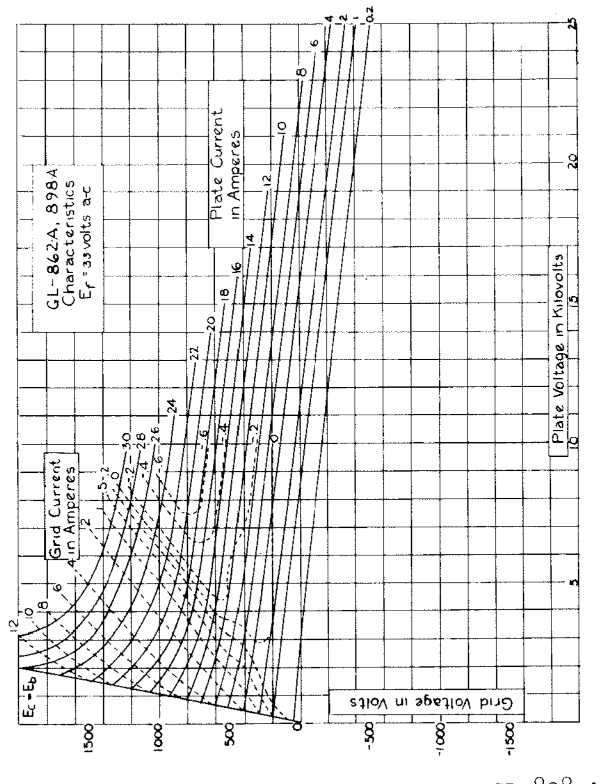
Series Resistor, ohms	10	20	40	50
Maximum Power Output of Rectifier, kilowatts	100	250	640	1600

† Averaged over any audio-frequency cycle
‡ At crest of audio-frequency cycle
§ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.



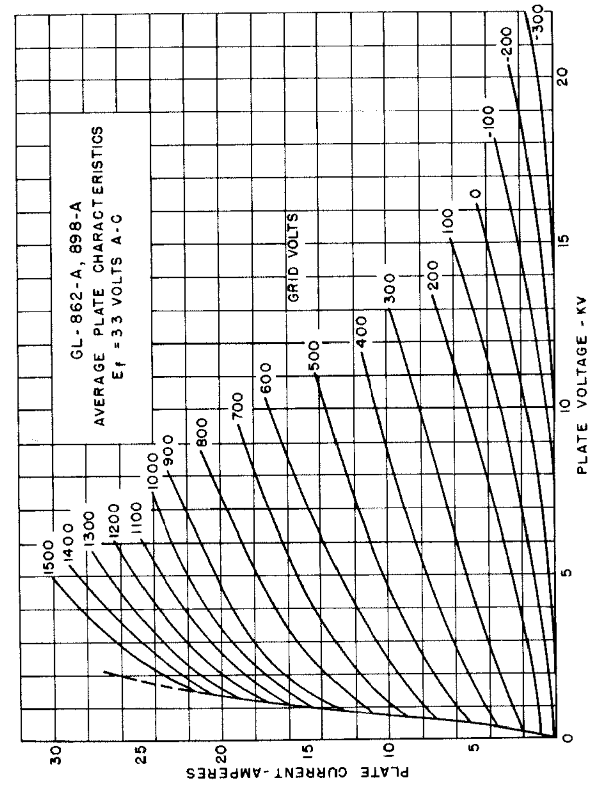
Typical Grid-plate Transfer Characteristic for Transmitting Tube GL-898-A

K-6966425 9-26-44



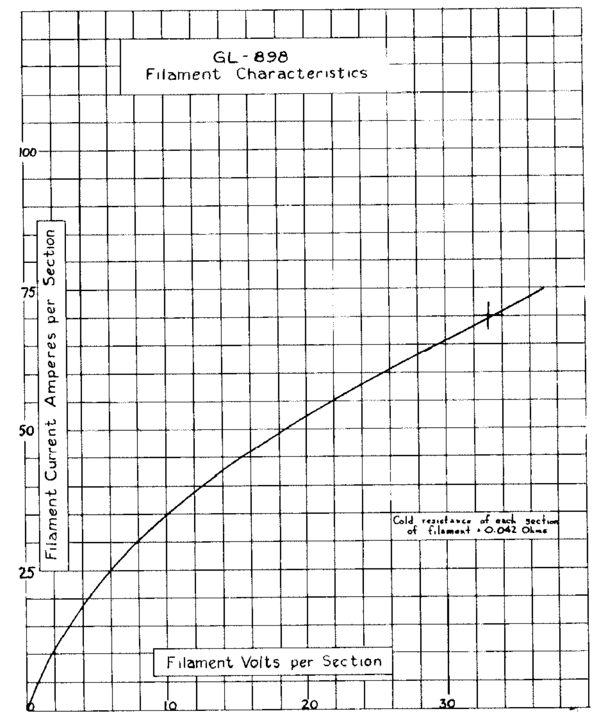
Characteristics for Transmitting Tube GL-898-A

K-6966424 4-5-44



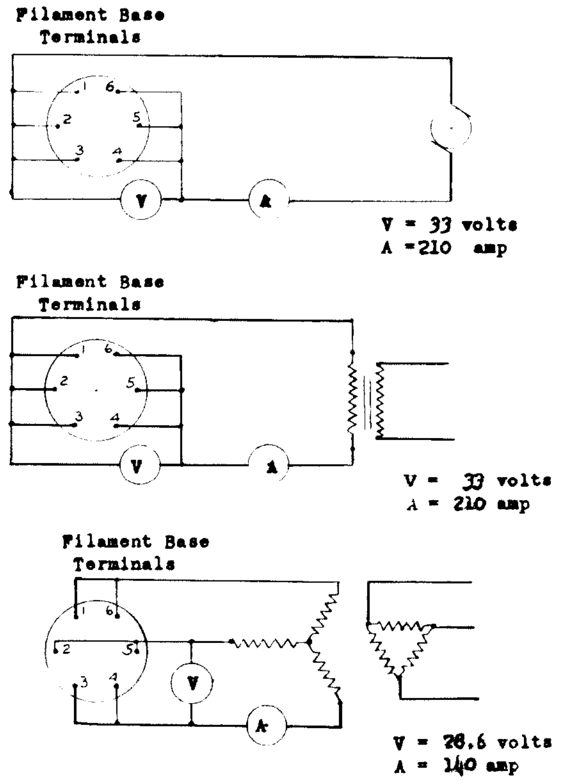
Average Plate Characteristics Transmitting Tube GL-898-A

K-6966423 9-26-44

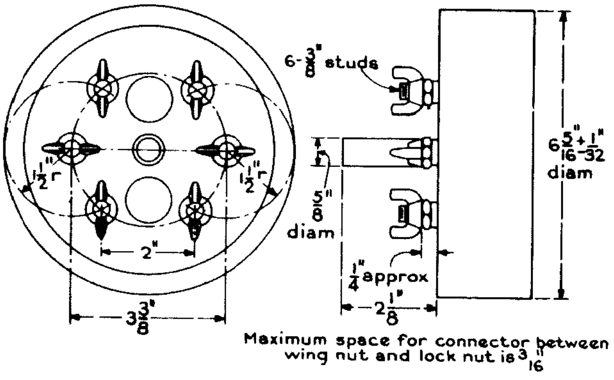


Filament Characteristics Transmitting Tube GL-898-A

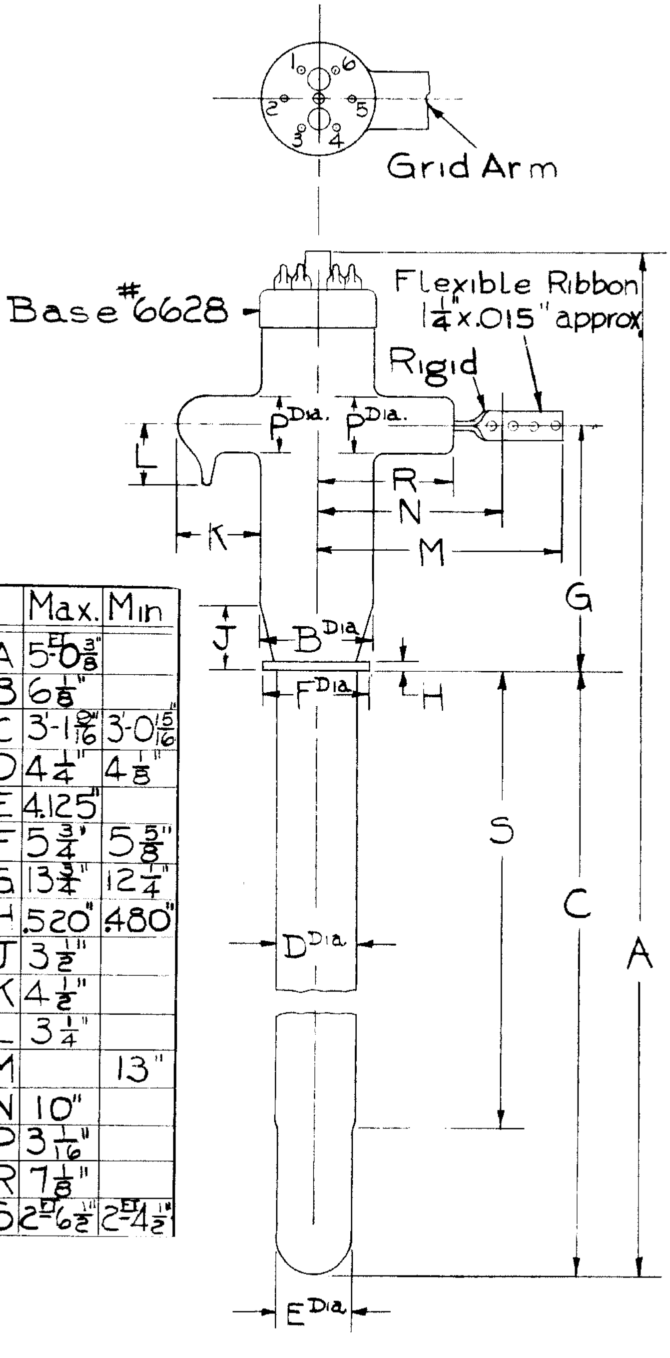
K-6966422 2-18-42



Filament Connections and Excitation Circuits
K-7050597 3-19-40



Top and Side View of Base No. 6628



	Max.	Min
A	5'-0 3/8"	
B	6 1/8"	
C	3'-1 9/16"	3'-0 15/16"
D	4 1/4"	4 1/8"
E	4.125"	
F	5 3/4"	5 5/8"
G	13 3/4"	12 1/4"
H	.520"	.480"
J	3 1/2"	
K	4 1/2"	
L	3 1/4"	
M		13"
N	10"	
P	3 1/16"	
R	7 1/8"	
S	2'-6 1/2"	2'-4 1/2"

Outline Transmitting Tube GL-898-A
K-5185285 3-6-43

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-1613 - - Description and Rating

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament - Indirectly heated	
Voltage, a-c or d-c	6.3 Volts
Current	0.7 Amperes
Grid-plate Transconductance, I_b= -31 ma	2500 Micromhos
Direct Interelectrode Capacitances*	
Grid-plate	0.26 μμf
Input	6.5 μμf
Output	13.5 μμf
Frequency for Maximum Ratings	45 Megacycles

MECHANICAL

Base Description - Small Wafer Octal 7-pin

Maximum Over-all Dimensions	
Length	3 1/4 Inches
Diameter	1 4/16 Inches
Net Weight, approximate	
Shipping Weight, approximate	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR, PLATE MODULATED
(Carrier Conditions Per Tube for Use With a Maximum Modulation Factor of 1.0)

	Typical Operation	Maximum Ratings	
D-c Plate Voltage	275	275	Volts
D-c Grid Voltage (Grid 1)‡	-35	-100	Volts
	12500		Ohms
D-c Grid Voltage (Grid 2)†	200	275	Volts
	7500		Ohms
D-c Plate Current	42	50	Milliamperes
D-c Grid Current, approximately	2.8	5	Milliamperes
D-c Screen Current	10		Milliamperes
Plate Input		11.5	Watts
Screen Input		2	Watts
Plate Dissipation		7	Watts
Peak R-F Grid Input Voltage	65		Volts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR, PLATE MODULATED (CONT'D)

	Typical Operation	Maximum Ratings	
Driving Power	0.16		Watts
Plate Power Output	6		Watts
D-c Heater-Cathode Potential		100	Volts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR
(Key down conditions per tube without modulation)§

	Typical Operation	Maximum Ratings	
D-c Plate Voltage	350	350	Volts
D-c Grid Voltage (Grid 1)Δ	-35	-100	
	10000		Ohms
D-c Grid Voltage (Grid 2)¶	200	275	Volts
	15000		Ohms
D-c Plate Current	50	50	Milliamperes
D-c Grid Current, approximate	3.5	5	Milliamperes
D-c Screen Current	10		Milliamperes
Plate Input		17.5	Watts
Screen Input		2.5	Watts
Plate Dissipation		10	Watts
Peak R-F Grid Input Voltage, approx	70		Volts
Driving Power, approximately	0.22		Watts
Plate Power Output, approximately	9		Watts
D-c Heater-Cathode Potential		100	Volts

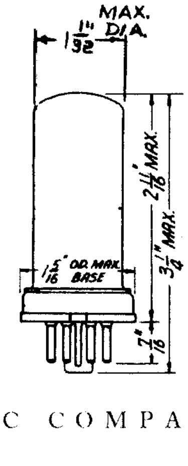
* With shell connected to cathode.
‡ Obtained by grid leak or by partial self-bias methods.
† From modulated fixed supply or modulated plate-voltage supply through resistor of value shown.
§ Modulation essentially negative, may be used if the positive peak of the Audio-frequency envelope does not exceed 115 per cent of the carrier conditions.
Δ From separate source, or from the plate-voltage supply with a voltage divider, or through a series resistor of the value shown.
¶ Obtained by grid resistor or other self- or fixed-bias method.

The 1613 can be operated at frequencies as high as 45 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 90 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

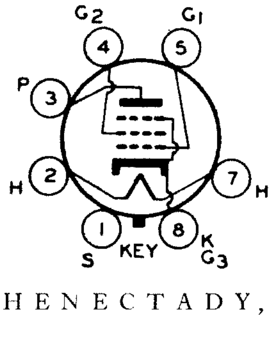
FREQUENCY	45	60	90	Megacycles
PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE AND PLATE INPUT				
Class C Plate Modulated	100	90	85	per cent
Class C Unmodulated	100	90	85	per cent

Tube Mounting Position
Vertical or Horizontal

Small Wafer
Octal 7-pin Base



Bottom View of Socket Connections



GENERAL ELECTRIC

Transmitting Tube GL-1614 - - Description and Rating

The GL-1614 is a beam power transmitting tube of the metal type capable of delivering an output of 21 watts in Class C radio-frequency telegraph service with only 0.1 watt of driving power.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

ELECTRICAL

Number of Electrodes	4	
Heater Voltage*	6.3	Volts
Heater Current	0.9	Ampere
Grid-plate Transconductance, Ib = 72 ma	6050	Micromhos
Direct Interelectrode Capacitances†, mmfd		
Grid-plate	0.4	
Input	10	
Output	12	

MECHANICAL

Base Description	Small Wafer Octal, 7-pin	
Net Weight (approx)	3	Ounces
Shipping Weight (approx)	1	Pound

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED
(Carrier conditions per tube for use with a max modulation factor of 1.0)
With Triode Connection, Grid No. 2 Tied to Anode

	Typical Operation	Maximum△ Ratings	
Filament Voltage	6.3	6.3	Volts
D-c Plate Voltage	325	325	Volts
D-c Grid Voltage		-125	Volts
From a fixed supply of	-85		Volts
From a grid resistor of	21000		Ohms
D-c Plate Current	65	70	Milliamperes
D-c Grid Current (approx)	4	10	Milliamperes
Plate Input		23	Watts
Plate Dissipation		14	Watts
Peak R-f Grid Input Voltage (approx)	102		Volts
Driving Power (approx)	0.4		Watts
Plate Power Output	11.5		Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED
(Carrier conditions per tube for use with a max modulation factor of 1.0)
With Tetrode Connection

	Typical Operation	Maximum△ Ratings	
Filament Voltage	6.3	6.3	Volts
D-c Plate Voltage	325	325	Volts
D-c Grid Voltage		-125	Volts
From a fixed supply of	-40		Volts
From a grid resistor of	20000		Ohms
D-c Screen Voltage‡		300	Volts
From a fixed supply of	245		Volts
From a series resistor of	10000		Ohms
D-c Plate Current	70	70	Milliamperes
D-c Grid Current (approx)	2	5	Milliamperes
Plate Input		23	Watts
Screen Input		2.5	Watts
Plate Dissipation		14	Watts
Peak R-f Grid Input Voltage (approx)	51		Volts
Driving Power (approx)	0.1		Watt
Plate Power Output	15		Watts

	Typical Operation	Maximum△ Ratings	
CLASS C R-F POWER AMPLIFIER AND OSCILLATOR			
(Key down conditions per tube without modulation)§			
Filament Voltage	6.3		Volts
D-c Plate Voltage	375	375	Volts
D-c Grid Voltage		-125	Volts
From a fixed supply of	-40		Volts
From a cathode resistor of	435		Ohms
From a grid resistor of	20000		Ohms
D-c Screen Voltage		300	Volts
From a fixed supply of	250		Volts
From a series resistor of	12500		Ohms
D-c Plate Current	80	110	Milliamperes
D-c Grid Current (approx)	2	5	Milliamperes
Plate Input		35	Watts
Plate Dissipation		21	Watts
Screen Input		3.5	Watts
Peak R-f Grid Input Voltage (approx)	51		Volts
Driving Power (approx)	0.1		Watt
Plate Power Output	21		Watts

* In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

† With shell connected to cathode.

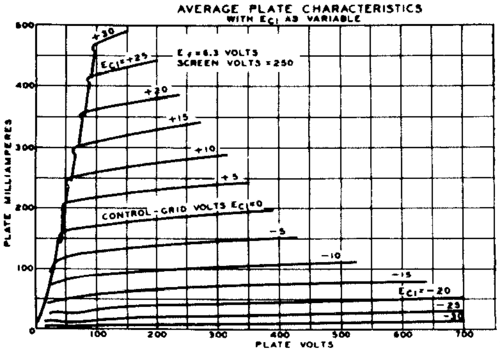
‡ Screen voltage preferably obtained from fixed supply, modulated simultaneously with plate voltage. Series voltage-dropping resistor connected to modulated plate-voltage supply may also be used.

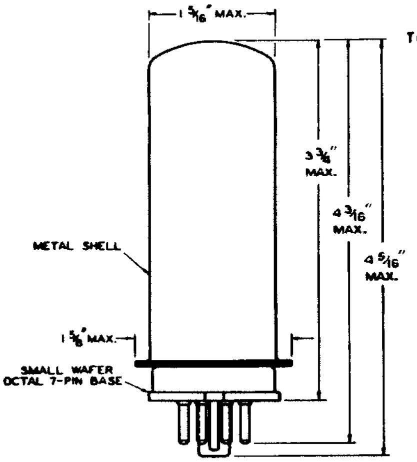
§ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

APPLICATION NOTES

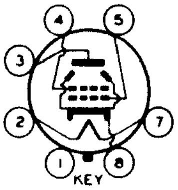
△ The GL-1614 can be operated at frequencies as high as 80 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 120 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

Frequency, megacycles	80	120
Max Permissible Percentage of Max Rated Plate Voltage and Plate Input		
Class C, plate modulated, triode) plate modulated, tetrode) Class C, telegraphy)	100	75





TUBE SYMBOL & BOTTOM VIEW OF SOCKET CONNECTIONS



PIN 1 - SHELL
PIN 2 - HEATER
PIN 3 - PLATE
PIN 4 - SCREEN
PIN 5 - GRID
PIN 7 - HEATER
PIN 8 - CATHODE

TUBE MOUNTING POSITION
VERTICAL OR HORIZONTAL

PRINTED IN U.S.A.

GENERAL ELECTRIC

Transmitting Tube GL-1616 - - Description and Rating

Description

The GL-1616 is a high-vacuum, half-wave rectifier. Since the tube is quick-heating, it is particularly useful in high-voltage devices where plate and filament voltages are applied simultaneously under full load conditions.

Technical Information

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Electrical

Filament-Filamentary	
Voltage	2.5 Volts
Current	5.0 Amperes
Tube Voltage Drop (See Curve)	75 Volts

Mechanical

Type of cooling, Convection (Maximum Ambient 60 C)

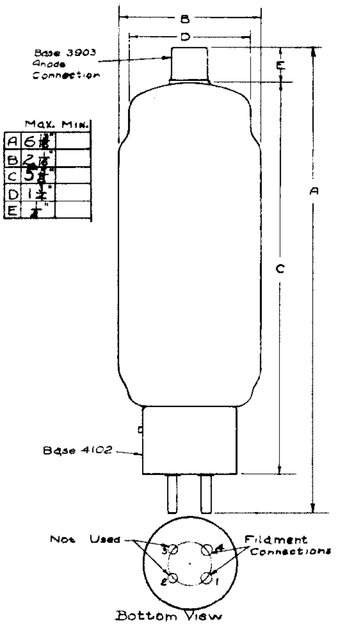
Base Description	Medium, 4-pin Bayonet, No. 4102
Maximum Over-all Dimensions (See Outline)	
Length	6-13/16" Max
Diameter	2-1/16" Max
Mounting Position	Vertical, Base down
Net Weight, approximate	3 oz
Shipping Weight, approximate	3 lb
Installation and Operation publication number	GEH-1213

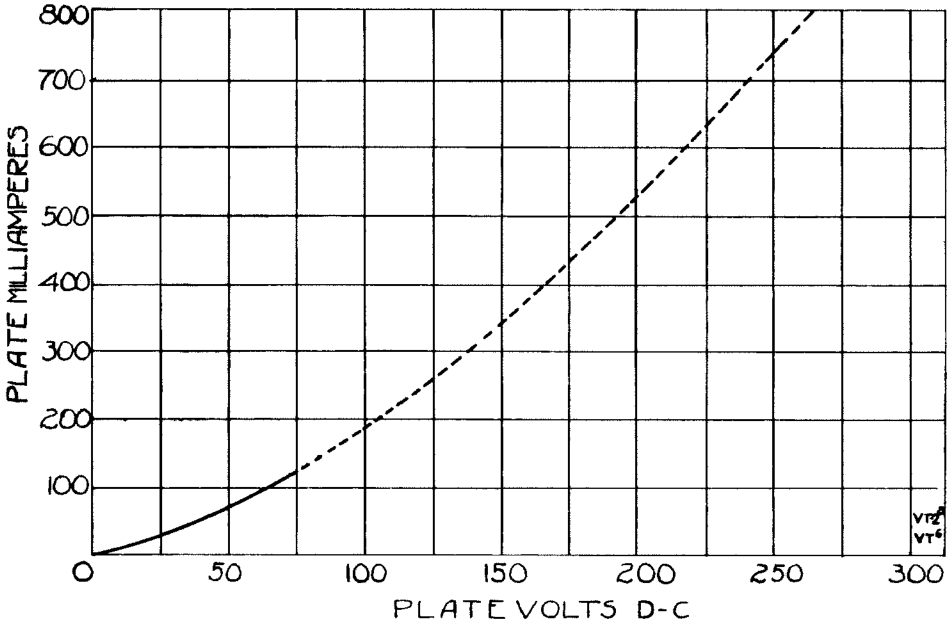
MAXIMUM RATINGS

Rectifier Operation

Peak Inverse Voltage	5500 Volts
Peak Plate Current	0.8 Amperes
Average Plate Current	0.13 Amperes
Surge Current, Maximum *	2.5 Amperes

* Equipment should be designed so that this value is not exceeded during switching operations.





Outline Rectifier
Tube GL-1616
K-6979172
July 17-1941

Average Plate Characteristic
K-6966495 July 12-1941

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.
9-43 (6M)
Filing No. 8850
Supersedes GET-976
PRINTED IN U.S.A.

GENERAL ELECTRIC

Transmitting Tube GL-1619 - - Description and Rating

The GL-1619 is a beam power transmitting tube of the metal type utilizing a coated filament to provide fast heating. The high power sensitivity and the quick-heating feature of this tube make it especially suited for use as an a-f or r-f amplifier, modulator, frequency multiplier, or oscillator in equipment where quick off-on operation is essential.

Operation of the 1619 with maximum ratings is practical at frequencies as high as 45 megacycles. Neutralization of the tube is generally unnecessary in adequately shielded circuits. In push-pull class AB_2 amplifier service, the 1619 will deliver over 35 watts of audio power with low distortion. Its maximum plate dissipation is 15 watts.

TENTATIVE CHARACTERISTICS AND RATINGS

Filament Voltage (a-c or d-c)	2.5	Volts
Filament Current	2	Amperes
Transconductance, For plate current of 50 ma	4500 approx	Micromhos
Direct Interelectrode Capacitances:		
Grid-plate	0.35	μμf
Input	10.5	μμf
Output	12.5	μμf
Base	Small Wafer Octal 7-pin	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

AS SINGLE-TUBE CLASS A_1† AMPLIFIER

D-c Plate Voltage	400 max	Volts
D-c Screen Voltage (Grid No.2)	300 max	Volts
Screen Input	3.5 max	Watts
Plate Dissipation	15 max	Watts
Typical Operation with Fixed Bias:		
D-c Plate Voltage	300	Volts
D-c Screen Voltage	250	Volts
D-c Grid Voltage (Grid No.1) †† °	-10	Volts
Peak A-f Grid Voltage	10	Volts
Beam-forming Plate Voltage **	0	Volts
Zero-signal D-c Plate Current	44	Milliamperes
Max-signal D-c Plate Current	46	Milliamperes
Zero-signal D-c Screen Current	4	Milliamperes
Max-signal D-c Screen Current	6	Milliamperes
Load Resistance	8800	Ohms
Total Harmonic Distortion	7	Per Cent
Max-signal Power Output (approx)	3	Watts

AS PUSH-PULL CLASS AB_1† AMPLIFIER

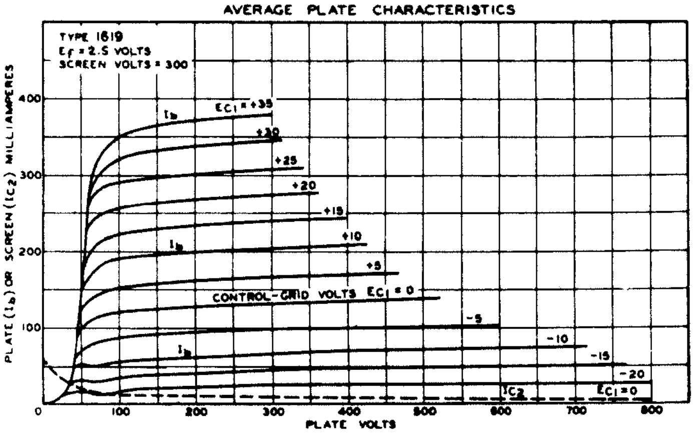
D-c Plate Voltage	400 max	Volts
D-c Screen Voltage (Grid No.2)	300 max	Volts
Screen Input *	3.5 max	Watts
Plate Dissipation*	15 max	Watts
Typical Operation with Fixed Bias: Unless otherwise specified, values are for 2 tubes.		
D-c Plate Voltage	400	Volts
D-c Screen Voltage	300	Volts
D-c Grid Voltage (Grid No.1) + °	-20	Volts
Peak A-f Grid-to-Grid Voltage	40	Volts
Beam-forming Plate Voltage **	0	Volts
Zero-signal D-c Plate Current	52	Milliamperes

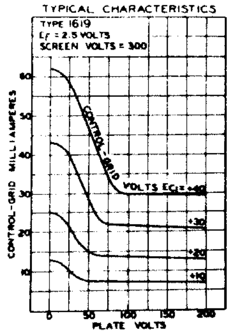
Δ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier condition.

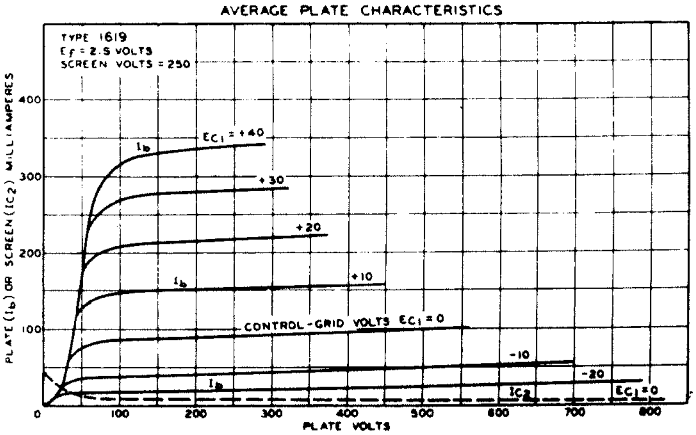
The maximum ratings apply only at frequencies below 45 megacycles. For operation at higher frequencies adequate ventilation and normal ambient temperatures must be maintained, and the plate voltage must be reduced as indicated.

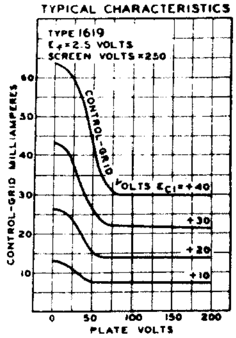
Frequency, Megacycles	45	90
Percentage of Maximum Rated Plate Voltage and Plate Input	100	75

The resonant frequency of the grid-plate circuit is approximately 200 megacycles.

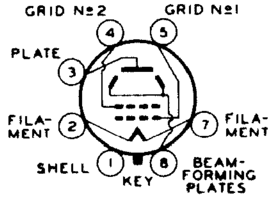


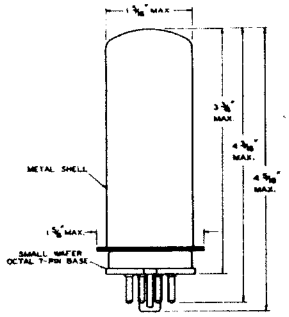






Bottom View of Socket Connections





GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

11-39 (2500)
Filing No. 8850

PRINTED IN U.S.A.

GENERAL ELECTRIC

Transmitting Tube GL-1623 - - Description and Rating

The GL-1623 is a three-electrode transmitting tube for use as an oscillator, radio-frequency amplifier, and Class B modulator. This tube is particularly useful as a self-excited oscillator in circuits which are subject to unusual conditions of wide plate-load variations because it is not critical to changes in grid excitation voltage.

TECHNICAL INFORMATION

These data are for reference only. For design information see the Specifications.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament Voltage, volts	6.3
Filament Current, amperes	2.5
Amplification Factor	20
Direct Interelectrode Capacitances, μμf	
Grid-plate	6.7
Grid-cathode	5.7
Plate-cathode	0.9

MECHANICAL

Base or Terminal Description	Medium 4-pin Ceramic, Bayonet
Net Weight, oz approx	3
Shipping Weight, lb approx	7

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B A-F POWER AMPLIFIER (TWO TUBES)

	Typical Operation		Maximum* Ratings	
Filament Voltage, volts	6.3			
	CCS	IC and AS	CCS	IC and AS
D-c Plate Voltage, volts	750	1000	750	1000
Max Signal Plate Current (per tube)†, ma			100	100
D-c Max Signal Plate Input (per tube)†, watts			75	100
Plate Dissipation† (per tube), watts			25	30
D-c Grid Voltage, volts	-25	-40		
Peak A-f Grid Input Voltage, volts	200	230		
Zero Signal Plate Current, ma	35	30		
Maximum Signal Plate Current, ma	200	200		
Max Signal Driving Power, approx watts	4	4.2		
Effective Load (plate-to-plate), ohms	8400	12000		
Max Signal Plate Power Output, watts	100	145		

CLASS B R-F POWER AMPLIFIER
Carrier conditions per tube for use with a max modulation factor of 1.0

Filament Voltage, volts	6.3			
	CCS	IC and AS	CCS	IC AND AS
D-c Plate Voltage, volts	750	1000	750	1000
D-c Grid Voltage, volts	-40	-50		
D-c Plate Current, ma	50	45	50	50
Plate Input, watts			37.5	45
Plate Dissipation, watts			25	30
Peak R-f Grid Input Voltage, volts	60	62		
Driving Power ‡, approx watts	1.4	1.7		
Plate Power Output, watts	12.5	16		

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED
Carrier conditions per tube for use with a max modulation factor of 1.0

	Typical Operation		Maximum* Ratings	
Filament Voltage, volts	6.3			
	CCS	IC and AS	CCS	IC and AS
D-c Plate Voltage, volts	600	750	600	750
D-c Grid Voltage, volts	-125	-125	-200	-200
D-c Plate Current, ma	83	100	83	100
D-c Grid Current, approx ma	25	20	25	25
Plate Input, watts			50	75
Plate Dissipation, watts			17.5	25
Peak R-f Grid Input Voltage, approx volts	200	215		
Driving Power, approx watts	5	4		
Plate Power Output, watts	38	55		

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR
Key down conditions per tube without modulation §

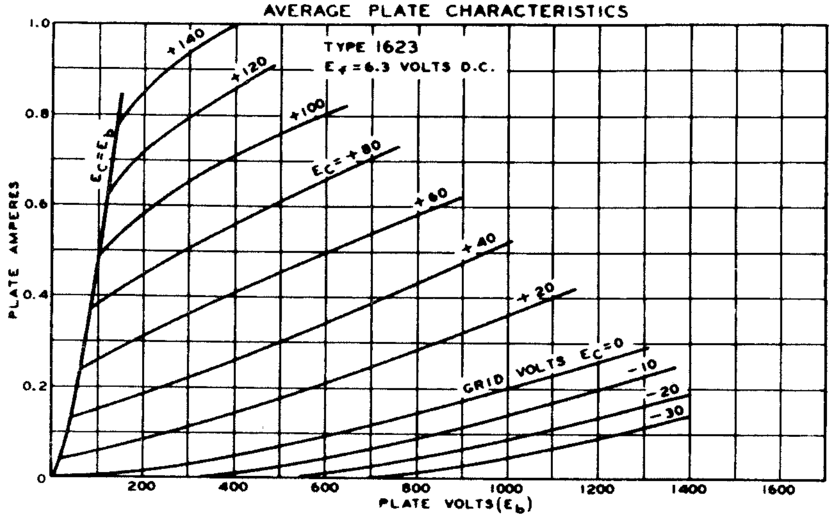
Filament Voltage, volts	6.3			
	CCS	IC and AS	CCS	IC and AS
D-c Plate Voltage, volts	750	1000	750	1000
D-c Grid Voltage, volts	-85	-90	-200	-200
D-c Plate Current, ma	100	100	100	100
D-c Grid Current, approx ma	17	20	25	25
Plate Input, watts			75	100
Plate Dissipation, watts			25	30
Peak R-f Grid Input Voltage, approx volts	200	215		
Driving Power, approx watts	2.5	3.1		
Plate Power Output, watts	55	75		

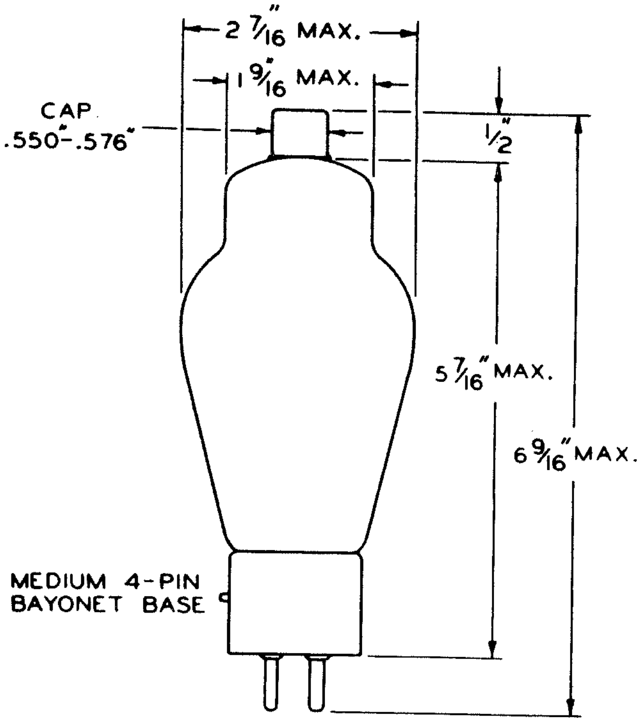
† Averaged over any audio-frequency cycle.
‡ At crest of audio-frequency cycle.
§ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

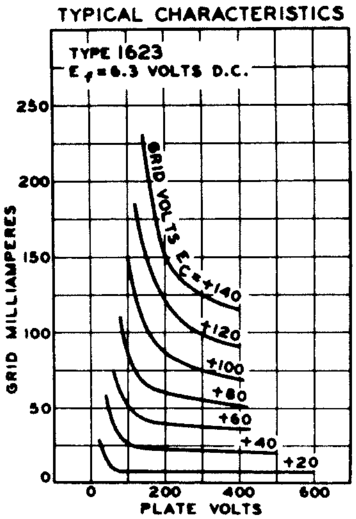
APPLICATION NOTES

* The GL-1623 can be operated at frequencies as high as 60 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 100 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

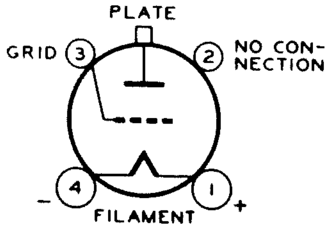
Frequency, megacycles	60	70	100
Maximum Permissible Percentage of Maximum Rated Plate Voltage and Plate Input			
Class B, R-f	100	93	88
Class C, plate modulated) unmodulated)	100	80	60







Top View of Socket Connections



GENERAL ELECTRIC
SCHENECTADY, N.Y.

4-40 (3M)
Filing No. 8850

PRINTED IN U.S.A.

GENERAL ELECTRIC

Transmitting Tube GL-1641 - - Description and Rating

The 1641 is a high-vacuum, full-wave rectifier for use in high-voltage d-c power supply devices operating from the alternating-current supply line.

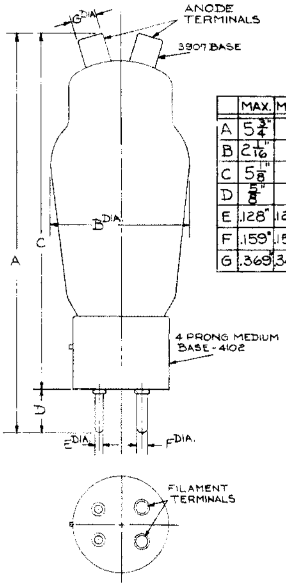
CHARACTERISTICS AND RATINGS

Filament Voltage	5 Volts
Filament Current	3 Amperes
Average Tube Voltage Drop, output current = 250 ma	61 Volts
Base Description	Medium 4-prong
Net Weight, approx	7 Ounces
Shipping Weight	3 Pounds

MAXIMUM RATINGS

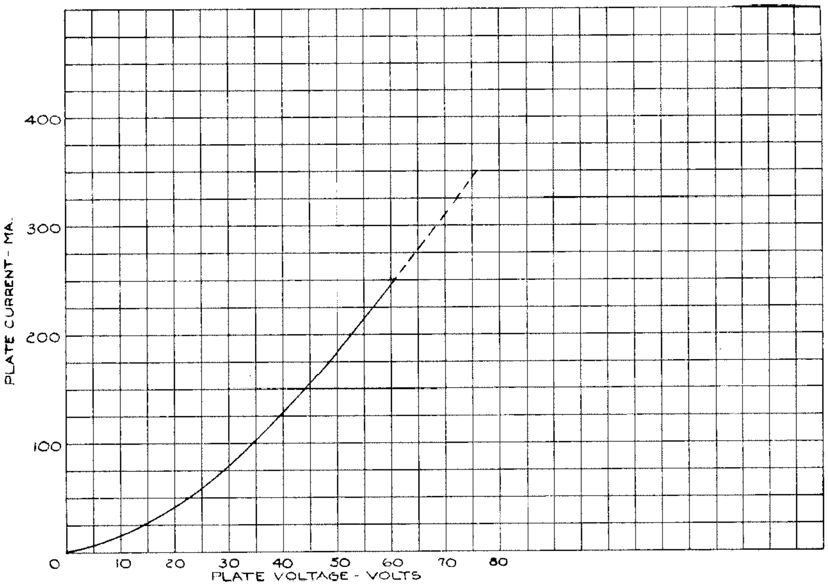
Condenser or Choke Input Filter

A-c Voltage per Plate, rms	750
Peak Inverse Voltage	2120 Volts
Output Current, d-c	250 Milliamperes



	MAX.	MIN.
A	5 3/4"	
B	2 1/16"	
C	5 1/8"	
D	5/8"	
E	.128"	.122"
F	.159"	.153"
G	.369"	.346"

Outline Transmitting Tube GL-1641
K-8074609 2-3-42



Average Plate Characteristic
K-8074610 2-3-42
EACH PLATE
E_f = 5.0V.A-C

GENERAL ELECTRIC COMPANY, SCHENECTADY,N.Y.
2-42 (3M)
Filing No. 8850

PRINTED IN U.S.A.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-8002--Description and Rating

The GL-8002 is a three-electrode transmitting tube designed for use as a radio-frequency power amplifier at high frequencies. Multiple leads for both the filament and grid connectors minimize the inductance to these electrodes. Maximum ratings may be used up to a frequency of 150 megacycles and reduced ratings up to 300 megacycles.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

General Design

Number of Electrodes	3
Filament Voltage	16 Volts
Filament Current	38 Amperes
Direct Interelectrode Capacitances, approximate	
Plate to Grid	8.7 uuf
Grid to Filament	10.2 uuf
Plate to Filament	0.90 uuf
Type of Cooling - Water and Forced Air	
Installation and Operation	GEH-1152

Maximum Ratings

CLASS B RADIO-FREQUENCY POWER AMPLIFIER
Carrier conditions per tube for use with maximum modulation factor of 1.0

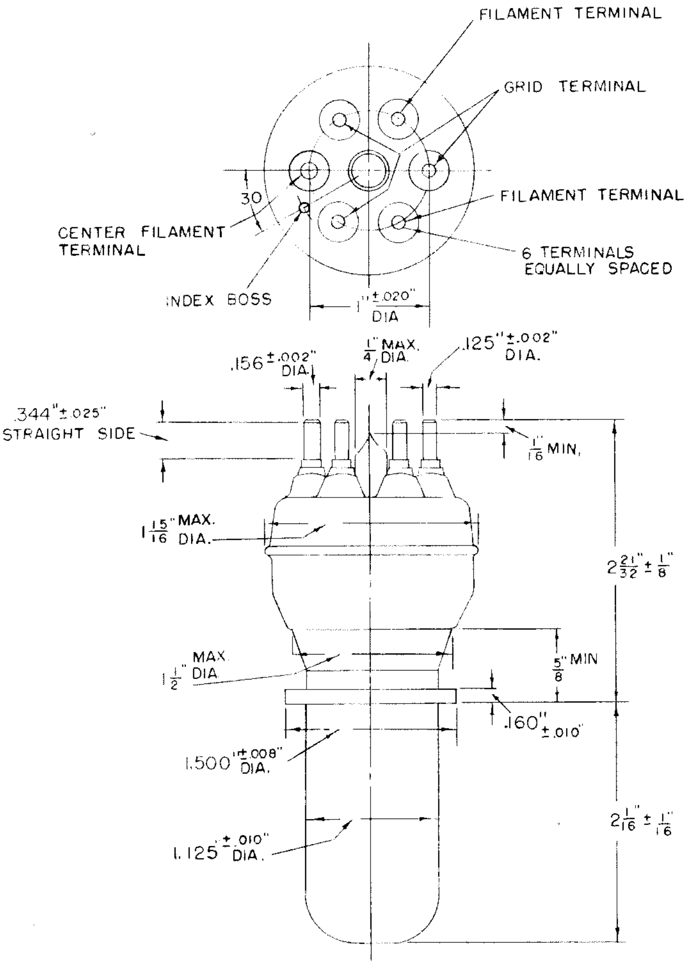
Plate Voltage, d-c	3500 Volts
Plate Current, d-c	0.6 Amperes
Plate Input	1800 Watts
Plate Dissipation	1200 Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR, PLATE MODULATED
Carrier conditions per tube for use with a maximum modulation factor of 1.0

Plate Voltage, d-c	2500 Volts
Grid Voltage, d-c	-500 Volts
Plate Current, d-c	0.5 Amperes
Grid Current, d-c	0.1 Amperes
Plate Input	1250 Watts
Plate Dissipation	750 Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR, TELEGRAPHY
Key down conditions per tube without modulation. Essentially negative modulation may be used if the positive peak of the a-f envelope does not exceed 115 per cent of the carrier conditions.

Plate Voltage, d-c	3500 Volts
Grid Voltage, d-c	-500 Volts
Plate Current, d-c	1.0 Amperes
Grid Current, d-c	0.1 Amperes
Plate Input	3000 Watts
Plate Dissipation	1200 Watts



Outline Transmitting Tube GL-8002
K-6912329 Mar. 16, 1944

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-8002-R -- Description and Rating

The GL-8002-R is a three-electrode transmitting tube designed for use as a radio-frequency power amplifier at high frequencies. Multiple leads for both the filament and grid connectors minimize the inductance to these electrodes. The anode is fitted with a special hub and cooling is obtained by forced air. Maximum ratings may be used up to a frequency of 120 megacycles and reduced ratings up to 200 megacycles.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

General Design

Number of Electrodes	3
Filament Voltage	16 Volts
Filament Current	38 Amperes
Direct Interelectrode Capacitances, approximate	
Plate to Grid	8.9 uuf
Grid to Filament	10.2 uuf
Plate to Filament	1.0 uuf
Type of Cooling - Forced Air	
Installation and Operation	GEH-1198

Maximum Ratings

CLASS B RADIO-FREQUENCY POWER AMPLIFIER

Carrier conditions per tube for use with maximum modulation factor of 1.0

Plate Voltage, d-c	3500 Volts
Plate Current, d-c	0.6 Amperes
Plate Input	1800 Watts
Plate Dissipation	1200 Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR, PLATE MODULATED

Carrier conditions per tube for use with a maximum modulation factor of 1.0

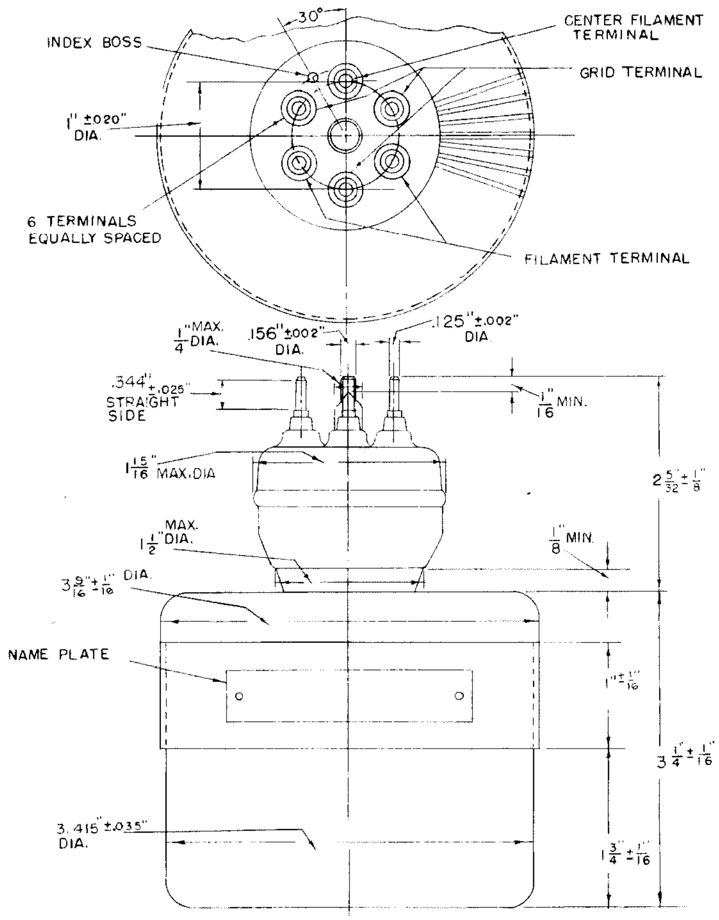
Plate Voltage, d-c	2500 Volts
Grid Voltage, d-c	-500 Volts
Plate Current, d-c	0.5 Amperes
Grid Current, d-c	0.1 Amperes
Plate Input	1250 Watts
Plate Dissipation	750 Watts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR, TELEGRAPHY

Key down conditions per tube without modulation. Essentially negative modulation may be used if the positive peak of the a-f envelope does not exceed 115 per cent of the carrier conditions.

Plate Voltage, d-c	3500 Volts
Grid Voltage, d-c	-500 Volts
Plate Current, d-c	1.0 Amperes
Grid Current, d-c	0.1 Amperes
Plate Input	3000 Watts
Plate Dissipation	1200 Watts

The air flow should be 100 cubic feet per minute and the temperature of the incoming air should not exceed 45 C. The glass temperature must not be allowed to exceed 150 C. Ordinarily, deflecting vanes diverting the outgoing air toward the terminal seals provide sufficient cooling.



Outline Transmitting Tube GL-8002-R

K-6912385 Mar. 16, 1944

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

3-44 (5M)
Filing No. 8850

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-8009--Description and Rating

The GL-8009 is a three-electrode power tube designed for use as a radio-frequency amplifier, oscillator, or Class B modulator. The plate is water-cooled and is capable of dissipating 12 to 20 kw, depending upon the class of service. The design of the terminal mount connections and the introverted anode minimize lead inductance. This tube is particularly suitable for high-frequency applications.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL DESIGN

Electrical

Filament Voltage	12.6 Volts
Filament Current	320 Amperes
Amplification Factor	20
Grid-plate Transconductance, I_b = 2.0	21000 Micromhos
Direct Interelectrode Capacitances, mu mu f	
Grid-plate	26
Grid-filament	29
Plate-filament	2.6
Installation and Operation	GEH-1152

Mechanical

Type of Cooling	Water and Forced Air
Water Flow	12-20 Gallons per Minute
Air Flow to Bulb, from a 3-in. Diam Nozzle	20 Cubic Feet per Minute
Net Weight	7 Pounds
Shipping Weight, approx	21 Pounds

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B A-F POWER AMPLIFIER (TWO TUBES)

	Typical Operation		Maximum* Ratings	
D-c Plate Voltage	7500	10000	10500	Volts
Max Signal Plate Current, per tube†			5	Amperes
D-c Max Signal Plate Input, per tube†			40	Kilowatts
Plate Dissipation, per tube†			15	Kilowatts
D-c Grid Voltage	-300	-430		Volts
Peak A-f Grid Input Voltage	1450	1690		Volts
Zero Signal Plate Current	1.0	1.0		Ampere
Max Signal Plate Current	7.0	7.0		Amperes
Max Signal Plate Input†	52	70		Kilowatts
Max Signal Driving Power, approx	250	225		Watts
Effective Load, plate-to-plate	2200	3200		Ohms
Max Signal Plate Power Output	30	45		Kilowatts

CLASS B R-F POWER AMPLIFIER

Carrier conditions per tube for use with a max modulation factor of 1.0.

	Typical Operation		Maximum* Ratings	
D-c Plate Voltage	7500	10000	10500	Volts
D-c Grid Voltage	-310	-430		Volts
D-c Plate Current	3.5	3	4	Amperes
Plate Input			32	Kilowatts
Plate Dissipation			20	Kilowatts
Peak R-f Grid Input Voltage	450	550		Volts
Driving Power‡, approx	500	500		Watts
Plate Power Output	8	10		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE-MODULATED

Carrier conditions per tube for use with a max modulation factor of 1.0.

D-c Plate Voltage	7500	10000	10500	Volts
D-c Grid Voltage	-1000	-1200	-1200	Volts
D-c Plate Current	3.0	3.6	3.6	Amperes
D-c Grid Current, approx	0.3	0.3	0.6	Ampere
Plate Input			36	Kilowatts
Plate Dissipation			12	Kilowatts
Peak R-f Grid Input Voltage, approx	1550	1770		Volts
Driving Power, approx	460	880		Watts
Plate Power Output	16	28		Kilowatts

CLASS C R-F POWER AMPLIFIER AND OSCILLATOR

Key-down conditions per tube without modulation§

D-c Plate Voltage	7500	10000	10000	10500	Volts
D-c Grid Voltage	-600	-800	-800	-1200	Volts
D-c Plate Current	5	4.5	6	6	Amperes
D-c Grid Current, approx	0.45	0.4	0.5	0.6	Ampere
Plate Input				60	Kilowatts
Plate Dissipation				20	Kilowatts
Peak R-f Grid Input Voltage, approx	1250	1400	1500		Volts
Driving Power, approx	560	550	750		Watts
Plate Power Output	27	34	45		Kilowatts

† Averaged over any audio-frequency cycle.

‡ At crest of audio-frequency cycle.

§ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

APPLICATION

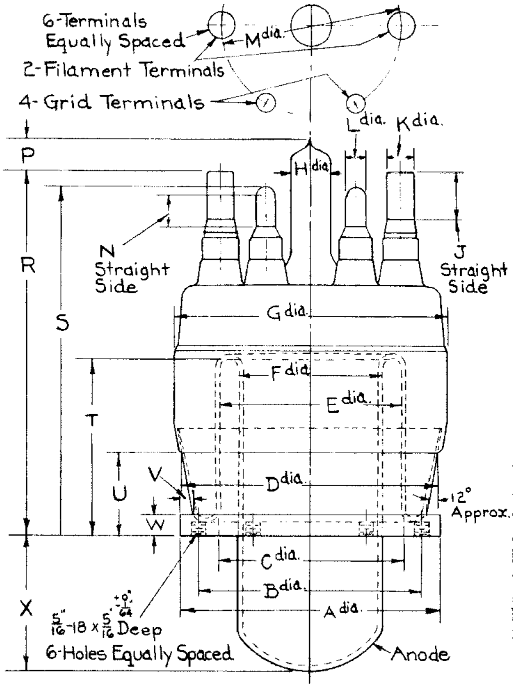
* The GL-8009 can be operated at maximum ratings in all classes of service at frequencies as high as 25 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown above.) The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 100 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

Frequency - Mc	25	50	75	100
Class B R-f				
Per Cent Max Plate Voltage	100	80	68	60
Per Cent Max Plate Input	100	94	85	75

Class C Plate-modulated				
Per Cent Max Plate Voltage and Plate Input	100	72	56	45
Class C				
Per Cent Max Plate Voltage and Plate Input	100	75	62	50

Plate Series Protective Resistors (see paragraph describing plate circuit under Installation in the Instructions)

Series Resistor, ohms	10	15	20	30
Max Power Output of Rectifier, kilowatts	40	100	250	640



	Max.	Min.
A	5.782"	5.718"
B	5.137"	5.113"
C	4.219"	4.155"
D	$5\frac{15}{16}$"	$5\frac{5}{8}$"
E	4.107"	4.017"
F	3.205"	3.135"
G	$6\frac{1}{4}$"	—
H	$1\frac{1}{4}$"	—
J	—	.930"
K	.630"	.620"
L	.442"	.432"
M	$4\frac{1}{8}$"	$3\frac{7}{8}$"
N	—	.650"
P	$\frac{1}{2}$"	—
R	8"	$7\frac{5}{8}$"
S	$7\frac{3}{4}$"	$7\frac{3}{8}$"
T	$3\frac{15}{16}$"	$3\frac{13}{16}$"
U	$2\frac{5}{8}$"	2"
V	—	$\frac{1}{4}$"
W	.520"	.480"
X	$3\frac{1}{8}$"	$2\frac{7}{8}$"

GENERAL ELECTRIC

Transmitting Tube GL-8010A-R - - Description and Rating

PRELIMINARY TECHNICAL INFORMATION

The GL-8010A-R is a three-electrode transmitting tube with an oxide-coated, indirectly heated cathode. The anode is fitted with a cooler for forced-air cooling. The close spacing of the parallel plane electrodes minimizes transit time, yet the interelectrode capacitances are sufficiently low to prevent excessive feedback within the tube. These features, together with the low lead inductance provided by the disk type terminals, result in a tube especially suitable for use as an ultra-high-frequency oscillator or power amplifier.

GENERAL DESIGN

ELECTRICAL

Cathode - Indirectly heated	
Heater Voltage	5.2 - 6.3 Volts†
Heater Current	1.75 - 2.25 Amperes
Heating Time	1 Minute
Amplification Factor	30
Transconductance at 0.040 Ampere	2000 umhos
Direct Interelectrode Capacitances	
Grid-plate	1.8 μμf
Grid-cathode	2.3 μμf
Plate-cathode	0.2 μμf

MECHANICAL

Over-all Dimensions	
Maximum Length	4 3/4 Inches
Maximum Diameter	1 1/2 Inches

Cooling

A small blower is required for forced-air cooling. Air flow must be sufficient to limit the glass temperature to 100 C at the hottest point.

Mounting

Plug and flexible leads to heater pins. Spring fingers on disks.

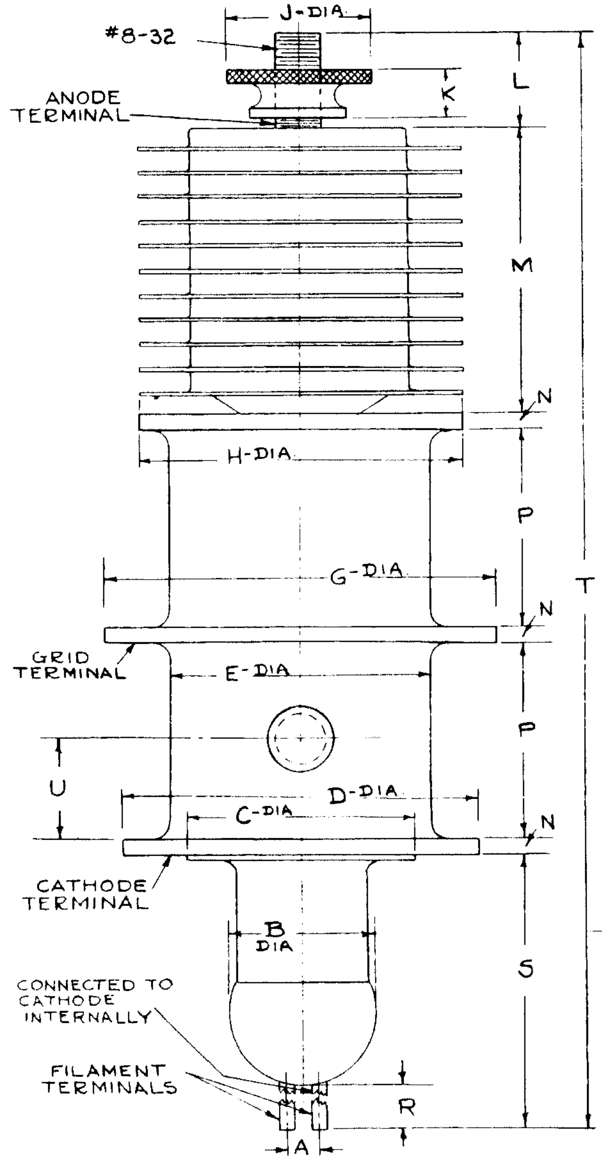
MAXIMUM RATINGS

Class C R-f Power Amplifier or Oscillator

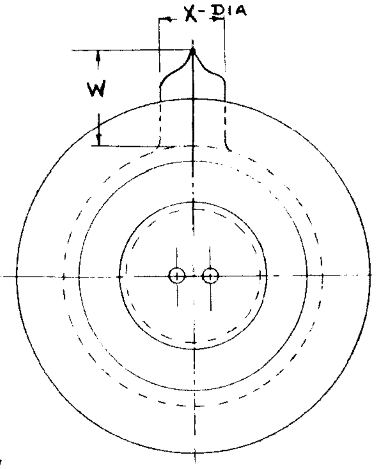
Maximum D-c Plate Voltage	1100 Volts
Maximum D-c Plate Current	100 Ma
Maximum D-c Plate Dissipation	50 Watts
Maximum D-c Grid Voltage	-500 Volts
Maximum D-c Grid Current	20 Ma
Maximum Frequency for Full Ratings	350 Mc

†The heater should be operated as near the lower voltage as is consistent with satisfactory tube operation.

*This supersedes Tube Type GL-8010-R



	MAX	MIN
A	.140"	.110"
B	$\frac{11}{16}$"	
C	$\frac{7}{8}$"	
D	$1\frac{13}{32}$"	$1\frac{11}{32}$"
E	$1\frac{1}{16}$"	$\frac{15}{16}$"
G	$1\frac{17}{32}$"	$1\frac{15}{32}$"
H	$1\frac{9}{32}$"	$1\frac{7}{32}$"
J	$\frac{9}{16}$"	
K	$\frac{9}{32}$"	
L	$\frac{3}{8}$"	
M	$1\frac{1}{4}$"	1"
N	.063"	.057"
P	$\frac{25}{32}$"	$\frac{23}{32}$"
R		$\frac{1}{4}$"
S	$1\frac{3}{8}$"	
T	$4\frac{3}{4}$"	
U	$\frac{7}{16}$"	$\frac{5}{16}$"
W	$\frac{7}{16}$"	
X	$\frac{5}{16}$"	



Outline Transmitting Tube GL-8010A-R
K-8075051 6-12-42

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

3-43 (2M)
Filing No. 8850

Supersedes GET-980A

PRINTED IN U.S.A.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-8012--Description and Rating

The GL-8012 is a high-perveance transmitting tube designed especially for use as an oscillator, r-f power amplifier, and frequency multiplier at the ultrahigh frequencies.

The tube has high plate efficiency at the higher frequencies because the tantalum plate and grid are closely spaced, thereby decreasing electron transit time between filament and plate. Lead inductance and resistance are minimized and neutralization is facilitated by the short, heavy, double grid and plate leads.

TECHNICAL INFORMATION

These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Electrical

Number of Electrodes	3	
Filament Voltage§	6.3	volts
Filament Current	1.92	amperes
Amplification Factor	18	
Direct Interelectrode Capacitances		
Grid-plate	2.8	uuf
Grid-cathode	2.7	uuf
Plate-cathode	0.35	uuf

Mechanical

Type of cooling	Forced Air	
Net Weight, approx	3	ounces
Shipping Weight, approx	1	pound
Installation and Operation	GEH-1258	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Class C R-F POWER AMPLIFIER - GRID-MODULATED
(Carrier conditions per tube for use with a max modulation factor of 1.0)

	Typical Operation	Maximum† Ratings	
Filament Voltage	6.3	6.3	volts
D-c Plate Voltage	1000	1000	volts
D-c Grid Voltage**	-135	-200	volts
D-c Plate Current	50	65	milliamperes
D-c Grid Current*, approx	4		milliamperes
Plate Input		50	watts
Plate Dissipation		40	watts
Peak A-f Grid Voltage	65		volts
Peak R-f Grid Input Voltage	155		volts
Driving Power*π, approx	3.5		watts
Plate Power Output	20		watts

	Typical Operation	Maximum† Ratings	
CLASS C R-F POWER AMPLIFIER AND OSCILLATOR - PLATE MODULATED			
(Carrier conditions per tube for use with a max modulation factor of 1.0)			
Filament Voltage	6.3		volts
D-c Plate Voltage	800	800	volts
D-c Grid Voltage∆	-105	-200	volts
From a grid resistor of	10000		ohms
D-c Plate Current	40	65	milliamperes
D-c Grid Current*, approx	10.5	20	milliamperes
Plate Input		33	watts
Plate Dissipation		27	watts
Peak R-f Grid Input Voltage, approx	145		volts
Driving Power*, approx	1.4		watts
Plate Power Output	22		watts
CLASS C R-F POWER AMPLIFIER AND OSCILLATOR			
(Key down conditions per tube without modulation)‡			
Filament Voltage	6.3		volts
D-c Plate Voltage	1000	1000	volts
D-c Grid Voltage◊		-200	volts
From a fixed supply of	-90		volts
From a grid resistor of	6400		ohms
From a cathode resistor of	1400		ohms
D-c Plate Current	50	80	milliamperes
D-c Grid Current*, approx	14	20	milliamperes
Plate Input		50	watts
Plate Dissipation		40	watts
Peak R-f Grid Input Voltage, approx	130		volts
Driving Power*, approx	1.6		watts
Plate Power Output	35		watts

§ The filament is center-tapped and the center lead is brought out of the tube. With this design, it is possible to minimize the effect of filament-lead inductance by connecting all three filament leads in parallel through r-f by-pass condensers. The center lead of this parallel connection should not be returned directly to the center-tap of the filament-transformer winding or to ground although it may be by-passed to either of these points if desired.

** Under typical operating conditions the grid voltage may be obtained from a fixed supply or by a cathode resistor of 2500 ohms.

* Subject to wide variations depending on the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits need less grid current and driving power, but plate circuit efficiency is sacrificed. The driving stage should be capable of delivering considerably more than the required driving power and should have a tank circuit of good regulation.

π At crest of audio-frequency cycle with modulation factor of 1.

∆ Obtained preferably from grid leak of value shown, or combination of grid leak with either fixed supply or suitably by-passed cathode resistor

‡ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

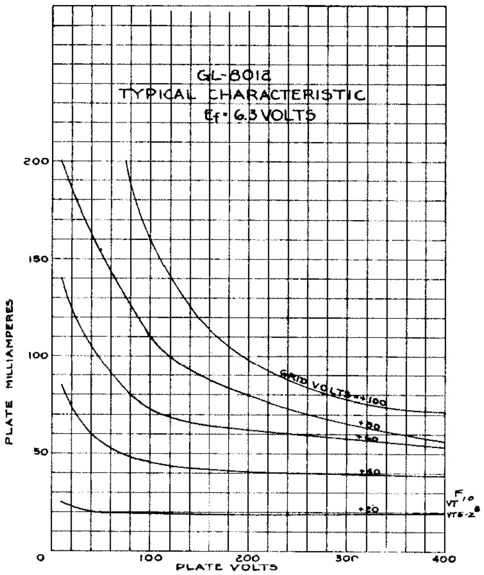
◊ Obtained from fixed supply, or grid resistor (6400), or by cathode resistor (1400). When the 8012 is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed

bias must be used to maintain the plate current at a safe value. With plate voltage of 1000 volts, a fixed bias of at least -40 volts should be used.

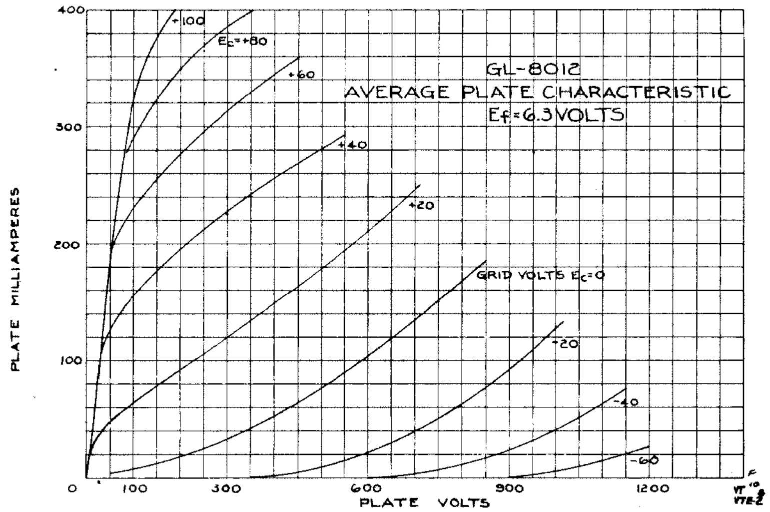
APPLICATION NOTES

† The GL-8012 can be operated at frequencies as high as 500 megacycles. As the frequency is raised, the efficiency and power output fall off. At 600 mc, an efficiency of about 35 per cent can be expected. Since the efficiency at 600 mc is relatively low, the plate of the tube has been designed to have an unusually high dissipation rating. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 600 mc for the various classes of service. Special attention should be given to adequate ventilation of the bulb of these frequencies. In cases where free circulation of air around the tube cannot be provided, forced air-cooling is recommended.

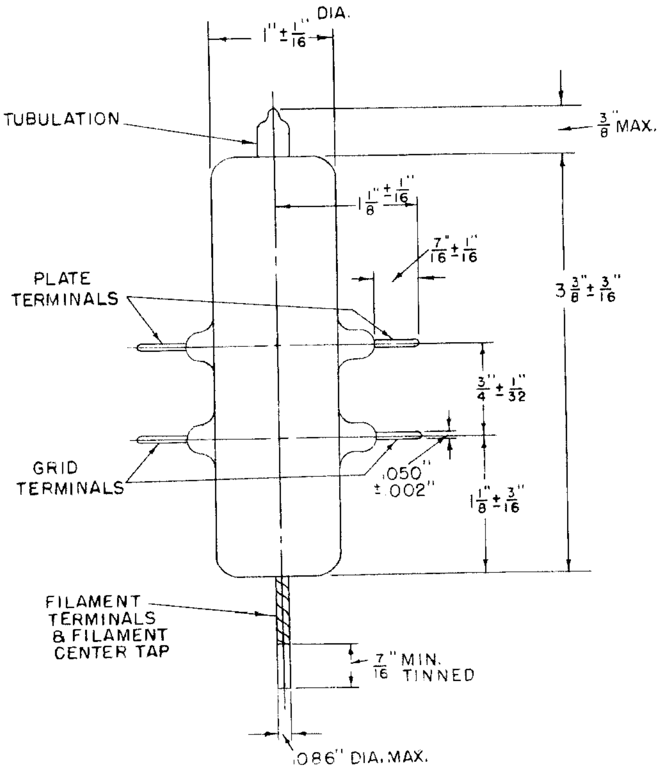
Frequency, megacycles	500	600
Max Permissible Percentage of Max Rated Plate Voltage		
Class C, grid-modulated	100	77
plate-modulated	100	63
telegraphy	100	63



Typical Characteristics GL-8012
K-8074671 4-18-42



Average Characteristics GL-8012
K-8074670 4-18-42



Tube Mounting
Position
Vertical Only

Outline Transmitting Tube GL-8012
K-8074669 6-3-44

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-8020--Description and Rating

TECHNICAL INFORMATION

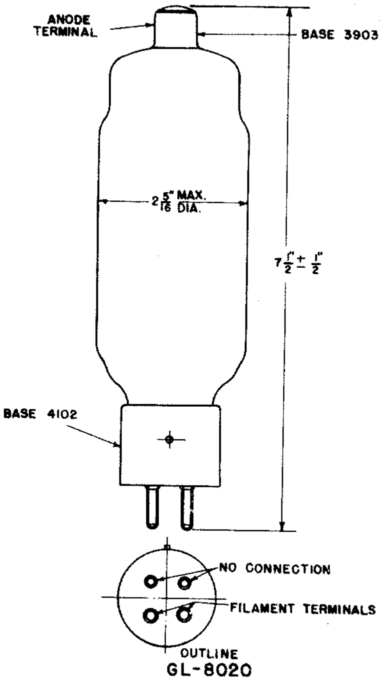
The GL-8020 is a half-wave, high-vacuum rectifier tube. These data are for reference only. For design information see the specifications.

GENERAL CHARACTERISTICS

Number of Electrodes	2	
Electrical		
Cathode - filamentary, thoriated tungsten		
Voltage	5	Volts
Current	5.5-6.5	Amperes
Heating Time (Before applying plate voltage)		
Tube Voltage Drop, I_b = 100 milliamperes	200	Volts
Capacitance, filament	1.4	Micromicrofards
Mechanical		
Type of Cooling - Convection		
Maximum Ambient Temperature 60 C		
Net Weight, approximate	3	Ounces
Shipping Weight, approximate	3	Pounds
Installation and Operation - ET-J15		

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

	Typical Operation	Maximum Ratings	
Rectifier Operation			
Peak Inverse Voltage		40,000	Volts
Peak Plate Current		750	Milliamperes
Average Plate Current		100	Milliamperes
Surge Limiting Diode Operation			
Maximum Filament Voltage	5.5	5.8	Volts
Peak Forward Voltage	100,000	12,500	Volts
Peak Plate Current, maximum			Amperes
Peak Plate Current, minimum available	2		Amperes
Average Plate Dissipation			Watts



Bottom View of Base
K-6979168 9-23-44

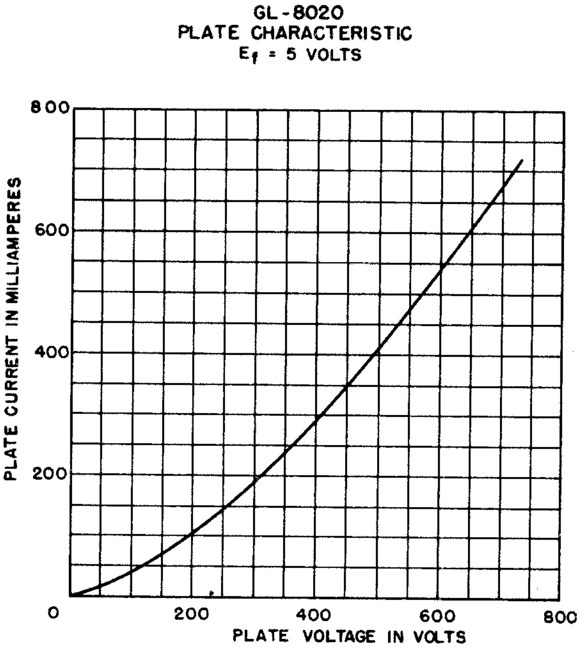


Plate Characteristic
K-5964496 9-26-44

Instruc-
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GENERAL ELECTRIC

Water-cooled Transmitting Tubes -- Installation and Operation

INSTALLATION

MECHANICAL

The handling of a transmitting tube requires care since a tube may be damaged if subjected to shock or vibration.

The tube should be tested upon receipt in the equipment in which it is to be used. The glass bulb, and particularly the glass area around the terminals, should be free from foreign matter. The leads become hot during operation so that any foreign material may become charred and cause puncture of the bulb.

The standard jacket supports the tube in the correct vertical position with the filament end up. The tube must not be subjected to vibration or shock.

The tube should be placed in its water jacket carefully, centered accurately, and then firmly fastened. Secure the tube in its jacket before making the electrical connections. When the jacket-clamping device is tightened, the contacts must seat properly on the tube flange. Proper seating in the jacket will be obtained by use of the standard gasket which is supplied with each tube. A new gasket must be used whenever a tube is placed in the jacket. It is recommended that the gasket be coated with a thin film of prodag to prevent sticking. The clamping device should first be tightened gently to prevent possible strain at the anode seal caused by improper seating of the flange. When this preliminary adjustment indicates the tube is seated properly, the jacket can be tightened securely. Do not tighten more than required to seat the anode flange properly on the gasket. If these precautions are not taken, the tube may be ruined by a glass crack caused by the uneven pressure on the flange. The grid and filament leads should not be taut, but should allow for some movement without placing a strain on the glass bulb. When electrical connections are made to the tube, care should be taken to exert as little bending movement as possible to the terminal pins. Before a readjustment of either the tube or its jacket is made, the leads should be disconnected. The retaining lugs, threads, and moving parts of the jacket may be kept free from rusting and sticking by coating them with a thin film of oil or oildag. Do not use an adhesive to seal the jacket against leaks because any sticking of the anode in the jacket may cause the tube to be damaged during its removal.

COOLING

The water-cooling system for the anode consists, in general, of a source of cooling water, a water jacket, and a feed-pipe system which carries the water to and from the jacket. When the anode is at a high potential above ground, the feed-pipe system should have good insulation qualities and proper design to reduce the leakage current to a negligible value.

An outlet water thermometer and a water flowmeter are advisable since water flow and temperature are important. The water must not be allowed to boil and the flow must be great enough to prevent steam bubbles forming on the plate surface. The temperature of the water at the outlet must not exceed 70 C. Proper functioning of the water-cooling system is of the utmost importance. Even a momentary failure of the water flow will damage the tube. It is, therefore, necessary to provide a method for preventing operation of the tube during such a condition. This may be accomplished by the use of water-flow circuit breakers, or interlocks, which open the filament and plate power supplies whenever the flow is insufficient or ceases.

The cooling water should flow upward along the anode and the piping must be arranged to avoid air traps in the jacket. Excessive water hammer may develop peak water pressures sufficient to deform the anode. Therefore, the piping system must be installed and operated properly so that water hammer does not occur. The pressure in the jacket must not exceed 80 pounds per square inch. If necessary, relief valves should be installed to prevent excessive pressure. The rate of water flow given on the Description and Rating Sheet is usually sufficient for all types of service. Under abnormal conditions an increased rate of flow may be necessary to prevent overheating The formation of steam may be detected by the use of an improvised stethoscope which may consist of six feet of insulating tubing with proper safety precautions. The stethoscope is pressed against the jacket at various points while suitable listening observations are made.

Distilled water is recommended for cooling because it greatly reduces the probability of scale formation on the anode during life. Scale hinders proper transfer of heat from the anode to the water. The mineral content, flow, heat dissipation, temperature, etc., of undis-

tilled water are so varied that no specific recommendations to prevent scale can be made. A sample of the cooling water should be analyzed before plans are made for the water system. In general, water which shows a hardness greater than 10 grains per gallon should not be used. Regardless of the kind of water used, the system should be kept free from accumulation of foreign material. A 10 per cent solution of hydrochloric acid will ordinarily dissolve scale in emergency cases. After such treatment, the anode should be rinsed carefully. The tube must be removed from its jacket for this treatment and, since frequent removals are objectionable because of danger from accidental breakage, it is desirable to prevent the formation of scale.

When forced-air cooling is called for on the Description and Rating Sheet, a system should be used which consists of a blower with air ducts of proper cross-sectional area which supply air to suitable air nozzles. In certain of the larger tubes (such as the 862 and the 898) both the bulb and the stem must be air cooled. In these tubes the nozzle which supplies air to the filament stem is incorporated in the base, and the nozzle which supplies air to the bulb is part of the water jacket and acts as a combination air nozzle and electrostatic shield.

Tubes which require forced air cooling on the stem only have an air nozzle incorporated in the cathode base.

Where the air nozzle is not part of the base or water jacket and the grid and filament terminals and the bulb require air cooling, a nozzle should be provided as part of the air-cooling system to direct the cooling air toward the top portion of the bulb.

The system should be arranged so that the temperature of the glass is not more than 150 C at the hottest point. Even when forced air cooling is not called for on the Description and Rating Sheet, free circulation of air must be provided to limit the temperature of the glass to this value. When there is inadequate ventilation or where a tube is used at the higher frequencies, forced air cooling may be required. In such cases a small blower may be used with suitable nozzles directing the air to the areas where cooling is necessary.

The cooling air must not contain any foreign matter. The air-cooling system should be electrically interconnected with the filament and plate supplies to prevent the application of voltage to the tube without suitable cooling. Precautions should be taken to insulate the air-cooling system from the anode and grid.

Air and water cooling of the GL-862 and -898 must be continued for ten minutes after power has been removed. For all other types water cooling only must be continued for two minutes after shutdown.

ELECTRICAL

Suitable meters should be provided for reading filament voltage, plate voltage, and current, and d-c grid current. A tube life recording meter (to read hours of operation) should also be provided.

The installation of all wires and connections must be made so that they do not lie on or close to the glass of the tube. Otherwise, severe trouble may arise from corona discharge or increased dielectric loss which will result in almost certain puncture.

The filament circuit carries a high current at low voltage. Therefore, the usual precautions should be taken against loss of voltage and heating due to poor connections. The filament connectors particularly should be large and make good contact.

In the case of the 8002 tube, three filament leads are brought out to terminals. These may be paralleled by capacitors to reduce the inductance of the filament circuit for the r-f returns. The filament sections must be operated in series from the filament supply. The center tap is to be used only for r-f or power supply returns.

The high initial rush of current through the filament when the switch is first closed should be limited by the use of some form of filament starter. This may be a system of time-delay relays cutting resistance out of the circuit or high-reactance filament transformer or a manual control. In any case, the starting current must never, even momentarily, exceed 1 1/2 times the normal value. Provision must be made also for accurate adjustment and maintenance of the filament voltage. The filament voltmeter should be connected to indicate the voltage at the filament terminals. The filament base should not be connected to ground or to any part of the circuit. Filament power may be alternating current or direct current. When alternating current is used, the plate and grid circuit returns should be made to the center point of the filament supply. When direct current is used, these returns should be made to the negative terminal.

For multiphase filament tubes it is essential that the connections for each type of filament voltage supply be made according to the circuit diagram to prevent distortion and possible failure of the filament.

The plate circuit should be provided with a time-delay relay to delay the application of plate voltage until the filament has reached at least 80 per cent of the normal voltage. It must be provided also with protective devices to prevent the tube from drawing a heavy overload. The coil of an instantaneous overload relay (set for slightly higher than normal plate current) placed in the ground lead of the plate return and operating to remove the plate voltage may be used for this purpose. The total time required for the operation of the relay and breaker should be in the order of one-tenth second and not more than one-sixth second. Plate series protective resistors should also be provided to protect the tube from excessive energy dissipation during instantaneous failure of insulation, within the tube or within the transmitter. The minimum value of this resistor which will give adequate protection with minimum power loss is given on the Description and Rating Sheet. Precautions must be taken so that no high capacitance is connected directly across the tube in such a manner that a disturbance within the tube will discharge appreciable energy from the capacitor.

The grid circuit should be provided with heavy conductors, carefully connected, in order to prevent overheating of the grid terminal due to r-f currents.

In the 8002 tube three grid leads are brought out to terminals. These may be used in parallel to reduce the inductance of the grid circuit. If desired, to reduce coupling, one lead may be used for the neutralizing circuit and the other two for the grid-excitation circuit. When the tube is used in an oscillator circuit at the higher frequencies, it may be necessary partially to neutralize the feedback in order to prevent excess grid excitation caused by the normal grid-plate capacitance.

If two or more tubes are used in the circuit, controls should be provided so that adjustment may be made to balance properly the plate current taken by each tube.

In Class B service, grid bias of excellent regulation is usually required.

In Class C service, the bias voltage may be supplied by a grid leak, or by a combination of grid leak and generator, grid leak and rectifier, or grid leak and cathode-bias resistor suitably by-passed. The combination method is particularly suitable to reduce distortion, especially in plate-modulated operation. Since the grid-bias voltage for Class C service is not particularly critical, correct circuit adjustment may be obtained with values differing widely from those indicated for this service.

The circuits should be arranged to prevent parasitic oscillations so that the tube will not be subjected to excessive voltages and currents.

OPERATION

When a new tube is first placed in operation, it should be operated without plate voltage for fifteen minutes at rated filament voltage. After this initial preheating schedule, plate voltage can be applied. Operate for fifteen minutes at approximately one-half the usual plate voltage. Full voltage may then be applied and the tube operated under the normal load conditions for a period of one hour or more. Every three months spare tubes should be given the preheating and initial operation schedule discussed above.

The filament should be operated at constant voltage rather than constant current and must be allowed to reach at least 80 per cent normal voltage before plate voltage is applied. Intermittent power supply interruptions may be allowed provided the time off does not exceed one second. If the tube is to be used at relatively low output, the plate current will be less than normal, requiring less than normal emission of the filament. The filament, therefore, may be operated at a voltage slightly lower than rated voltage, giving longer life. The permissible reduction in filament voltage may be checked by reducing the filament voltage with the transmitter under normal operation to a value where reduction in output or increase in distortion can just be detected. The filament voltage must then be increased by an amount equivalent to the maximum percentage regulation of the filament supply voltage. Care must be taken that sufficient emission is provided. Otherwise, instability of operation or excessive distortion may be experienced, or the rated plate dissipation of the tube may be exceeded. From the viewpoint of tube life, it is usually economically advantageous to provide good regulation of the filament voltage. For example, if the filament is operated continuously at 6 per cent above normal voltage, the evaporation life will be reduced to approximately one-half.

When a three-phase or six-phase a-c filament-supply voltage is used, the phase voltages must all balance within 15 per cent during the filament starting period. During normal operation the phase voltages must never, even momentarily, exceed 10 per cent unbalance.

If the apparatus in which the tube is used is to be idle for periods not exceed-

ing two hours, voltage should be maintained on the filament. However, if desired, provision may be made to reduce the filament voltage to approximately 80 per cent of the rated value during the stand-by. Where stand-by periods exceed two hours the filament voltage may be removed.

When direct-current filament excitation is used, the filament leads should be reversed every 500 hours of operation.

Maximum ratings and typical operating conditions for each recommended class of service are given on the Description and Rating Sheet. The amplifier classifications used are those given in the Report of the Standards Committee of the Institute of Radio Engineers.

The output values given in the tabulation on the Description and Rating Sheet are approximate tube outputs under certain typical operating conditions. These must not be used as output ratings; circuit losses must be subtracted from the tube output in calculating the useful output.

The approximate anode dissipation may be calculated from the following expression:

$$P_{(kilowatts)} = n\left(\frac{T_2 - T_1}{4}\right)$$

in which (T_1) is the known initial temperature of the cooling water in degrees centigrade, (T_2) the temperature of the water at the water jacket outlet in degrees centigrade, and (n) the water flow in gallons per minute.

In determining the value of plate voltage for normal operation, the line voltage fluctuation, load variation, and manufacturing variations must be estimated so that the maximum rated values will not be exceeded.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced to approximately one-half the rated value to prevent damage to the tube or associated apparatus. After correct adjustment has been made with the tube operating smoothly and without excessive heating of the cooling water or the glass bulb, the plate voltage may be raised in several steps to the desired value. Adjustments should be made at each step for optimum operation.

In case of overload and resultant overheating of the tube, the vacuum may be impaired. When the quantity of gas is not too great, the tube may be operated to bring about an electrical cleanup of the gas. The first step in the process should be a short period of operation at a plate voltage of one-half the normal value. The plate voltage should then be increased to the normal value and the tube allowed to operate for a period of one hour or more. In severe cases it may be possible to age the tube by operating with a series resistor in the plate supply. Short periods of operation may be conducted at each step as the resistor is reduced until stable operation at the normal plate voltage is obtained.

Before turning off the water preparatory to removing the tube, be sure that the inner electrodes are below red heat. Do not force the tube when removing it from the jacket. Release the securing device so that it will not stick, then manipulate the tube carefully to avoid putting strains on the glass. If sticking does occur, rotate the tube gently back and forth, at the same time raising it carefully.

/ See Description and Rating Sheet

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ELECTRONICS DEPARTMENT
GENERAL ELECTRIC

Transmitting Tube GL-816--Installation and Operation

INSTALLATION

The BASE of the 816 fits the standard 4-contact socket which should be installed to hold the tube in a vertical position with the base down. The plate connection is made to the cap at the top of the bulb.

The CONDENSED-MERCURY temperature of the 816 should be maintained between 20 C (68 F) and 60 C (140 F). This temperature can be measured with a thermocouple or a small thermometer attached with a minimum amount of putty at a point near the base end of the bulb. Lower than recommended condensed-mercury temperature raises the potential at which the tube starts and is unfavorable for long filament life. Higher than recommended condensed-mercury temperature decreases the potential at which the tube starts and is favorable for long filament life but reduces the peak inverse voltage which the tube can stand.

The COATED FILAMENT should be operated at the rated value of 2.5 volts under average operating conditions. The filament voltage, measured at the tube terminals, should not vary more than ± 5 per cent from the rated value. This tolerance should include the effects of regulation caused by transmitter-modulation load as well as the normal power-supply regulation. Less than the recommended filament voltage may cause a high voltage drop with consequent bombardment of the filament and eventual loss of emission. Greater than the rated voltage will also shorten the life of the filament.

CAUTION SHOULD BE OBSERVED WHEN THE FILAMENT VOLTAGE IS MEASURED BECAUSE THE FILAMENT CIRCUIT IS AT HIGH D-C POTENTIAL.

The filament of the 816 should be allowed to come up to operating temperature before the plate voltage is applied. For average conditions, the delay should be approximately 10 seconds. If there is evidence of arc-back in the tube, the delay should be increased. In radio transmitters during "standby" periods, the filament should be kept at its rated voltage to avoid delay in "coming back". A protective relay is desirable in the plate circuit to prevent automatically the application of plate voltage until the filament has reached operating temperature.

When an 816 is first placed in service, the filament should be operated at normal voltage for approximately five minutes without plate voltage in order to distribute the mercury properly. This procedure need not be repeated unless, during subsequent handling, the mercury is spattered on the filament and plate.

The 816 should be isolated from the transmitter as much as possible in order to avoid the detrimental effects of electromagnetic and electrostatic fields. These fields tend to produce breakdown in the mercury vapor, are detrimental to tube life and make filtering difficult. External shielding should be used when the tubes are in proximity to these external fields. R-f filtering should be used when the tubes are affected by r-f voltages. When shields are used, special attention must be given to adequate ventilation and to the maintenance of normal condensed-mercury temperature.

OPERATION

Filter circuits of either the condenser-input or the choke-input type may be used. If the condenser-input type of filter is used, special attention must be given

to the instantaneous peak value of the a-c input voltage which is about 1.4 times the rms value as measured with an a-c voltmeter. It is important, therefore, that the filter condensers (especially the input condenser) have a sufficiently high breakdown rating to withstand this instantaneous peak value. With the condenser-input type of filter, the peak plate current of the tube is considerably higher than the load current. When choke-input to the filter is used, the peak plate current is substantially reduced. This type of filter is preferable from the standpoint of obtaining the maximum continuous d-c output current from the 816 under the most favorable conditions.

Two or more 816's may be connected in parallel to give a corresponding increase in output current over a single tube. In this service, a stabilizing resistor of approximately 50 ohms should be connected in series with each plate in order that a proportionate share of the total load current will be carried by each tube. In special cases where it is desirable to minimize the small power loss caused by the voltage drop through the stabilizing resistor, an inductance of approximately one-third henry may be connected in series with the plate lead of each tube in place of the stabilizing resistor. The inductance has the added advantage of limiting the peak current to each tube, which is especially desirable when a condenser-input type of filter is used.

3-44 (10M)
Filing No. 8850

GENERAL ELECTRIC

Transmitting Tube GL-807 - - Installation and Operation

Installation

The base of the 807 fits a standard five-contact socket which may be installed to hold the tube in any position.

The heater voltage, under the maximum screen and plate dissipation conditions, should never fluctuate so that it exceeds 7.0 volts.

The heater should be operated at normal filament voltage during stand-by periods. If the stand-by periods exceed two hours the filament current may be shut off

The cathode circuit of the 807 should be connected to the electrical midpoint of the heater circuit when the heater is operated from an a-c supply. When the heater is operated from a d-c source, the cathode circuit should be connected to the negative heater-supply lead. In circuits where the cathode is not directly connected to the heater, the potential difference between them should not exceed 100 volts. If the use of a large resistor is necessary between heater and cathode in some circuit designs, it should be by-passed by a suitable filter network to avoid the possibility of hum.

The plate of the 807 shows no color when the tube is operated at its maximum plate-dissipation rating for each class of service.

The screen voltage may be obtained from a separate source, from a potentiometer, or from the plate supply through a series resistor, depending on the service in which the tube is used (see OPERATION). When the screen voltage is obtained from a separate source, or from a potentiometer, plate voltage should be applied before or with the screen voltage. Otherwise, with voltage on the screen only, the screen current may rise high enough to cause excessive screen dissipation. When screen-voltage regulation is not an important factor, the series-resistance method for obtaining screen voltage is desirable because of its simplicity and because it limits the d-c power input to the screen. The screen should not be allowed to attain a temperature corresponding to more than a barely perceptible red color. This temperature corresponds to the screen input values shown under CHARACTERISTICS.

It is, perhaps, not too well known that the screen current is a very sensitive indication of plate-circuit loading and that screen current rises excessively (often to the point of damaging the tube) when the amplifier is operated without a load. Therefore, care should be taken when tuning an 807 under no-load conditions in order to prevent exceeding the screen-input rating of the tube.

A protective device, such as a high-voltage fuse, should be used to protect both the screen and plate against overloads. When a potentiometer of poor regulation or a series resistor is used for obtaining the screen voltage, the protective device should be placed in the common positive high-voltage supply lead. It should remove the high-voltage supply when the d-c plate current reaches a value 50 per cent greater than normal. When the screen voltage is obtained from a separate source or from a potentiometer of good regulation, a protective device should also be placed in the screen-supply lead. It should remove the screen voltage when the d-c screen current reaches a value of 50 per cent greater than normal.

Shielding and isolation of the input and output circuit are necessary for stable operation. In some cases where the tube is used as an r-f amplifier, neutralization may be necessary to prevent feedback. The r-f impedance between the screen and cathode must be kept low, usually by means of a suitable by-pass condenser. The capacitance of this condenser may be in the order of 0.01 to 0.1 microfarad. In telephone service when the screen is modulated, a smaller capacitance may be required in order to avoid excessive a-f by-passing. However, if the capacitance is too small, r-f feedback may occur between plate and control grid, depending on the circuit layout, operating frequency, and power gain of the stage. A-f by-passing difficulties can usually be eliminated if the screen by-pass condenser is replaced by a series-tuned circuit to resonate at the operating frequency. The

series-tuned circuit presents a high impedance to audio frequencies but a very low impedance to its resonant frequency.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate and screen voltage. This may be done by means of a protective resistance of about 3000 ohms in series with the positive high-voltage supply lead. When a fixed screen supply is used, a protective resistor of about 10,000 ohms should also be employed in the screen lead.

Operation

In push-pull Class AB2 audio service, the 807 may be operated as shown under CHARACTERISTICS. The values cover operation with fixed bias and have been determined on the basis that some grid current flows during the most positive swing of the input signal.

In Class B r-f service, the 807 may be supplied with screen voltage from a separate source or from a potentiometer connected across the plate supply. Control-grid bias may be obtained from a battery, from a rectifier of good regulation, or from a cathode resistor, suitably bypassed for both audio and radio frequencies.

In plate-modulated Class C r-f service, GL-807 can be modulated 100 per cent. The screen voltage should preferably be obtained through a voltage-dropping resistor connected in series with the modulated plate-voltage supply. The screen voltage may also be obtained from a separate source, or from a potentiometer across the plate-voltage supply. In this case, modulation of the screen voltage can be accomplished either by connecting the screen to a separate winding on the modulation transformer, or by connecting it through a blocking condenser to a tap on the modulation transformer or choke. With the latter method, an a-f choke of suitable impedance should be connected in series with the screen-supply lead. Control-grid bias should be obtained from a grid leak or from a combination of either a grid leak and cathode resistor or grid leak and fixed supply.

In Class C r-f telegraph service, the GL-807 may be operated with screen voltage by any of the methods shown under INSTALLATION. Grid bias may be obtained by any convenient method.

When more radio-frequency power output is required than can be obtained from a single 807, the push-pull or the parallel connection may be used. Two tubes connected in push-pull or parallel will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage necessary to drive a single tube. With either connection, the driving power required is approximately twice that for single-tube operation while the grid bias is the same as that for a single tube. The push-pull arrangement has the advantage of cancelling even-order harmonics from the output and of simplifying the balancing of high-frequency circuits. The circuits should be arranged to prevent parasitic oscillations so that the tube will not be subjected to excessive voltages and currents.

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

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ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-842 -- Installation and Operation

INSTALLATION

The base pins of the 842 fit the standard 4-contact socket. The socket should be installed to hold the tube in a vertical position with the base down. If it is necessary to place the tube in a horizontal position, the socket should be mounted with the filament-pin openings one vertically above the other so that the plate will be in a vertical plane (on edge).

The bulb of this tube becomes very hot during continuous operation. For this reason it should not come in contact with any metallic body nor be subjected to drops or spray of liquid. Free circulation of air should be provided.

The filament of the 842 is of the thoriated-tungsten type. It may be operated either from an a-c or a d-c source. An a-c supply is generally used because of its convenience. The grid voltages shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS are based on a-c filament operation. When direct current is used on the filament, the circuit returns should be connected to the negative filament terminal. A suitable voltmeter should be connected permanently across the tube filament terminals to provide a ready check of the filament voltage. This voltage should not vary more than plus or minus 5 per cent from the rated value, otherwise, a loss of filament emission may result. When the apparatus in which the tube is used is idle for periods not exceeding two hours, the filament should be maintained at its rated voltage during the "standbys".

The plate of the 842 shows no color at the maximum plate-dissipation rating of 12 watts for class A service.

Overheating of the GL-842 by severe overload may decrease filament emission. The activity of the filament can sometimes be restored by operating it at rated voltage for ten minutes or more with no voltage on the plate or grid. The process may be accelerated by raising the filament voltage to 9.0 volts (not higher) for a few minutes. In order to prevent overheating due to improper circuit adjustments, to overloading, or to loss of grid bias, the plate circuit should be provided with a protective device such as a fuse. This device should instantly remove the plate voltage when the d-c plate current reaches a value 50 per cent greater than normal.

In order that the maximum ratings given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS will not be exceeded, changes in plate and filament voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus must be determined. An average value of plate and filament voltage should then be chosen so that under the usual voltage variation, the maximum rated voltages will not be exceeded.

When a new circuit is tried, or when adjustments are made, the plate voltage should be reduced in order to prevent damage to the tube or associated apparatus in case the circuit adjustments are incorrect.

OPERATION

As a class A audio-frequency amplifier or modulator, the GL-842 is capable of delivering 3 watts of audio power with not more than 5 per cent second-harmonic distortion. Typical operating conditions for single-tube operation are shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS. Grid bias may be obtained from a separate source or from a cathode-bias resistor. This resistor may be by-passed

depending on design requirements. The use of an unby-passed resistor will reduce distortion but at the same time decrease power sensitivity. If by-passing is used, it is important that the by-pass condenser be sufficiently large to have negligible reactance at the lowest frequency to be amplified.

In cases where the input circuit to the 842 is resistance- or impedance-coupled, the d-c resistance in the grid circuit should not be made too high. A resistance value of 1.0 megohm for one 842 is the recommended maximum when cathode bias is used. With fixed bias, the d-c resistance in the grid circuit should not exceed 0.25 megohm.

If more audio power output is desired than can be obtained from a single tube, two or more tubes can be operated in parallel or in push pull. The parallel connection provides twice the output of a single tube with the same input-signal voltage. The push-pull connection requires twice the input-signal voltage, but has in addition to the increase in power, a number of important advantages over single-tube operation. Distortion due to even-order harmonics and hum due to plate-supply ripple voltages are either eliminated or decidedly reduced through cancellation in the output circuit. Because harmonic distortion is reduced, appreciably more than twice single-tube output can be obtained by using a plate-to-plate load resistance only slightly larger than the value for single-tube operation.

If the bias for the tubes in push pull is supplied by a single cathode resistor, a large by-pass condenser should be used across the resistor to minimize distortion. With either the parallel or the push-pull circuit, the d-c grid bias is the same as for a single tube. When a number of tubes are operated in parallel or in push pull, it may be necessary to provide individual adjustment of grid bias to insure that the plate dissipation of each tube does not exceed the maximum rated value. This can be accomplished by means of a tapped C-supply, or by means of a variable cathode-bias resistor for each tube. A separate filament-supply winding is necessary for each tube that is individually biased with a cathode resistor. When tubes are operated in parallel, a noninductive resistance of 10 to 100 ohms should be placed in series with each grid lead, at the tube socket, to prevent parasitic oscillations.

3-44 (4M)
Filing No. 8850

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-837--Installation and Operation

Installation

The 12.6-volt heater of the 837 may be operated from either an a-c or a d-c supply. It is designed to operate under normal conditions of line-voltage or battery-voltage variation. In radio transmitters during "stand-by" periods, the heater should be maintained at its rated voltage for convenience in promptly resuming transmission. If the stand-by periods exceed two hours, the filament current may be shut off. In circuits where the heater and cathode are not directly connected together, the potential difference between them should not exceed 100 volts. If the use of a large resistor is necessary between heater and cathode in some circuit designs, it should be by-passed by a suitable filter network to avoid the possibility of hum.

Other installation requirements are similar to those for the 802. (See publication GEH-1116).

Operation

In Class B r-f pentode service, the 837 is supplied with unmodulated d-c plate voltage. The grid is excited by r-f voltage modulated at audio frequency in one of the preceding stages. Under these conditions, the plate dissipation is greatest when the carrier is unmodulated. The screen voltage should be obtained from a separate source or from a potentiometer connected across the plate supply. The suppressor voltage may be obtained from any fixed d-c supply. In cases where the suppressor draws current, the supply should be a battery or other d-c source of good regulation. Control-grid bias may be obtained from a battery, from a rectifier of good voltage regulation, or from a cathode resistor, suitably by-passed for audio and radio frequencies.

In suppressor-modulated Class C r-f service, the 837 is supplied with unmodulated d-c plate voltage. The control grid is supplied with unmodulated r-f voltage, and the suppressor with negative d-c voltage modulated at audio frequency. The screen voltage should be obtained through a resistor in series with the plate supply (see INSTALLATION). The d-c suppressor voltage may be obtained from any fixed supply. Control-grid bias for this service may be obtained from a grid leak, from a cathode resistor, or from a fixed supply. The cathode resistor should be by-passed for audio and radio frequencies. The grid-leak method has the advantage of simplicity and of automatically biasing the grid in proportion to the excitation voltage available. Special care must be observed with the use of this system because the accidental removal of the excitation will cause the plate current to rise to an excessive value. The use of a protective device designed to remove the screen and plate voltages on excessive rises of plate current will minimize the danger of overload (see INSTALLATION). Control-grid bias is not critical so that correct adjustment may be obtained with widely different values.

In grid-modulated Class C r-f pentode service, the 837 is supplied with an unmodulated r-f grid voltage and with a d-c grid bias that is modulated at audio frequencies. Grid bias should be obtained from a fixed supply. The plate is supplied with unmodulated d-c voltage. The audio power required in this service must be sufficient only to meet the peak power requirement of the grid of the Class C amplifier on the positive crest of the input signal. The screen voltage should be obtained from a separate source or from a potentiometer connected across the plate supply. The suppressor voltage may be obtained from a battery or from a fixed supply of good regulation.

In plate-modulated Class C r-f pentode service, the 837 can be modulated 100 per cent. The screen voltage may be obtained from a fixed supply, or through a voltage-dropping resistor in series with the modulated plate supply. The screen voltage must be modulated with the plate voltage so that the ratio of

screen voltage to plate voltage remains constant. Modulation of a fixed screen-voltage supply can be accomplished either by connecting the screen to a separate winding on the modulation transformer or by connecting it through a blocking condenser to a tap on the modulation transformer or choke. With the latter method, an a-f choke of suitable impedance for low audio frequencies should be connected in series with the screen-supply lead. The suppressor voltage may be obtained from any fixed supply. Control-grid bias may be obtained from a grid leak, or from a combination of either grid leak and fixed supply or grid leak and cathode resistor The cathode resistor should be by-passed for audio frequency and radio frequency. The combination method of grid leak and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion effects by bias-supply compensation. Grid bias voltage for this service is not particularly critical.

In plate-modulated Class C r-f tetrode service, the 837 is capable of being modulated 100 per cent. Grids No. 2 and 3 are connected together as the screen. The screen voltage may be obtained through a voltage-dropping resistor in series with the unmodulated plate-voltage supply. In this case, the series resistor develops its own modulating voltage. The screen voltage may also be obtained from a separate source, or from a potentiometer across the plate-voltage supply, provided the screen voltage is modulated as discussed under plate-modulated Class C r-f amplifier service (pentode connection) for a fixed screen supply. Control-grid bias considerations are the same as those for plate-modulated Class C pentode service.

In Class C r-f telegraph service with the pentode connection, the 837 may be supplied with suppressor and screen voltage by any of the methods shown under INSTALLATION. Control-grid bias may be obtained by any convenient method.

In Class C r-f telegraph service with the tetrode connection, the 837 is operated with grids No. 2 and 3 connected together as the screen. The screen voltage may be obtained by any of the methods shown under INSTALLATION. Control-grid bias may be obtained by any convenient method.

As a pentode or tetrode oscillator (crystal or self-excited), the 837 may be operated under the conditions shown for Class C telegraph services. Because the internal shielding in this tube is unusually effective, it is generally necessary to introduce external feedback in those circuits which depend on the control-grid-to-plate capacity for oscillation. This may be done by the use of a small condenser not larger than 2 to 3 μμf connected between control grid and plate.

If more radio-frequency power output is required than can be obtained from a single 837, the push-pull or the parallel connection may be used. For example, two tubes connected in push-pull or in parallel will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage; the push-pull connection requires twice the r-f excitation voltage necessary to drive a single tube. With either connection, the driving power required is approximately twice that for single-tube operation while the grid bias is the same as for a single tube.

The push-pull arrangement has the advantage of balancing high-frequency circuits to ground and of canceling the even-order harmonics from the output. If parasitic oscillations occur in the parallel or push-pull circuits, a non-inductive resistor of 10 to 100 ohms and a choke coil or other suitable network connected in series with the grid lead of each tube, as close to the socket connection as possible, will often prevent the oscillations.

3-44 (6M)
Filing No. 88850

Supersedes
GEH-1106A

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-800—Installation and Operation

Installation

The base of the 800 fits the standard 4-contact socket, such as the Type UR-542A. The socket should be installed to hold the tube in a vertical position with the base either up or down. The filament terminals are connected to the two large base pins; the grid and plate leads are brought out to separate metal caps at the top of the bulb (for connections, see Description and Rating Sheet).

The filament of the 800 is of the thoriated-tungsten type. The filament voltage should not vary more than plus or minus 5 per cent from the rated value; otherwise, a loss of filament emission may result. It is recommended that, in intermittent service when the average number of daily transmissions is greater than 100, the filament be maintained at 80 per cent of normal voltage during stand-by periods. If the number of transmissions is less than 100 per day, the filament power should be removed during stand-by periods.

The plate of the 800 shows no color at the maximum plate-dissipation rating for each class of service.

Overheating of the 800 by severe overload may decrease filament emission. Filament activity can sometimes be restored by operating the filament at rated voltage for ten minutes or more with no voltage on the plate or grid. This process may be accelerated by raising the filament voltage to 9 volts (not higher) for a few minutes. The positive high-voltage supply lead of the 800 should be provided with a protective device, such as a high-voltage fuse, to prevent the tube from drawing excessive plate current. This device should remove the high-voltage supply when the d-c plate current reaches a value 50 per cent greater than normal.

In order that the maximum ratings given under CHARACTERISTICS will not be exceeded, changes in plate and filament voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus, must be determined. An average value of plate and filament voltage should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate voltage. This may be done conveniently by means of a resistance of about 8000 ohms in series with the high-voltage plate lead. The rated plate voltage of this tube is high enough to be dangerous to the user. Care should be taken during the adjustment of circuits, especially those in which the exposed circuit parts are at the high d-c plate potential.

Operation

In Class B modulator or a-f amplifier service, two 800's are used in a balanced circuit, each tube amplifying half the time. The input transformer should be designed to give good frequency response when operated into an open circuit, such as that represented by the grid circuit of the Class B stage when the signal amplitude is small. It should also be designed to handle the required input power for a strong signal. The output transformer should be designed so that the resistance load presented by the modulated Class C amplifier is reflected as the recommended plate-to-plate load in the Class B a-f stage. Grid bias may be obtained from a battery or other d-c source of good regulation. It should not be obtained from a high-resistance supply such as a grid leak, nor from a rectifier, unless the latter has exceptionally good voltage regulation.

In Class B r-f service, the 800 is supplied with unmodulated d-c plate voltage. The grid is excited by r-f voltage modulated at audio frequency in one of the preceding stages. Under these conditions, the plate dissipation is greatest when the carrier is unmodulated. Grid bias may be obtained from a battery, from a rectifier of good regulation, or from a cathode-bias resistor, suitably by-passed for audio and radio frequencies.

The maximum plate voltage values shown under CHARACTERISTICS for Class B

services may be used provided the plate current for each service is limited so that the respective maximum plate-input rating is not exceeded. In like manner, the maximum plate-current values may be used provided the plate voltage for each service is limited so that the respective maximum plate-input rating is not exceeded.

In plate-modulated Class C r-f service, the 800 may be supplied with grid bias from a grid leak, or from a suitable combination of either grid leak and fixed supply, or from a grid leak and cathode-bias resistor. The cathode resistor should be suitably by-passed for audio and radio frequencies. The combination methods are particularly desirable because distortion effects are minimized by bias-supply compensation. Grid-bias voltage is not particularly critical so that correct adjustment may be obtained with values differing widely from those indicated for this service.

In Class C r-f telegraph service, the 800 may be supplied with grid bias by any convenient method.

The 800 may be operated at maximum ratings in all classes of service at frequencies as high as 60 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under CHARACTERISTICS.) The tabulation* shows the highest percentage of maximum plate voltage and power input that can be used at 60, 75, and 120 mc for any class of service.

If more radio-frequency power output is required than can be obtained from a single 800, the push-pull or the parallel connection may be used. For example, two tubes connected in push-pull or in parallel will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage; the push-pull connection requires twice the r-f excitation voltage necessary to drive a single tube. With either connection, the driving power required is approximately twice that for single-tube operation while the grid bias is the same as for a single tube. The push-pull arrangement has the advantage of balancing high-frequency circuits to ground and of cancelling the even-order harmonics from the output. If parasitic oscillations occur in the parallel or push-pull circuits, a noninductive resistor of 10 to 100 ohms and a choke coil or other suitable network connected in series with the grid lead of each tube, as close to the grid terminal as possible, will often prevent the oscillations.

* See Description and Rating Sheet.

4-44 (8000)
Filing No. 88850

Superseding GEH-1109A

GENERAL ELECTRIC

Transmitting Tube GL-843—Installation and Operation

Installation

The base pins of the 843 fit the standard five-contact socket which may be installed to operate the tube in any position. However, operation of the tube in the base-up position is least preferable.

The bulb of this tube becomes very hot during continuous operation. Free circulation of air, therefore, should be provided. Care should be taken that the bulb does not come in contact with any metallic object nor be subjected to the drops or spray of liquid.

The heater of the 843 is designed to operate at 2.5 volts. The heater supply may be either alternating current or direct current; alternating current is usually more convenient. The voltage across the heater terminals should be checked periodically. In radio transmitters during "stand-by" periods, the heater should be maintained at its rated voltage for the convenience of the operator in promptly resuming transmission.

The cathode should preferably be connected directly to a midtap on the heater winding or to a center-tapped resistor across the heater supply. If this is not done, the potential difference between cathode and heater should be limited to 45 volts.

The plate dissipation of the 843 (the difference between input and output) should never exceed the maximum value given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS. The plate should not show color under any condition of operation.

A d-c milliammeter should be used in the plate circuit in order that the plate current can always be known. Under no conditions should the d-c plate current exceed the maximum values given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.

Heavy leads and conductors together with suitable insulation should be used in all parts of the r-f plate tank circuit in order that the losses, due to the r-f voltages and currents, can be kept at a minimum. These losses are especially noticeable at the higher frequencies.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced in order to prevent damage to the tube or associated apparatus in case the circuit adjustments are incorrect. It is advisable to use a protective resistance of about 3000 ohms in series with the plate lead during such adjustments.

Operation

As a Class A audio-frequency amplifier, the 843 is capable of delivering 1.6 watt of audio-frequency power with very low distortion. Typical operating conditions are shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.

Grid bias for Class A service may be obtained from a separate voltage source or by means of a self-bias resistor. The proper value of this resistor for use with a single tube is 1000 ohms at a plate voltage of 350 volts, and 1400 ohms at a plate voltage of 425 volts. The cathode resistor should be shunted by a condenser which is large enough to minimize degenerative effects at low audio frequencies.

If more audio output is desired than can be obtained from a single 843, two 843's may be operated in parallel or in push-pull. The parallel connection provides twice the output of a single tube without an increase in grid-signal voltage. The push-pull connection will give slightly more than twice the output at the same grid bias but requires twice the input signal.

When a group of 843's is operated in Class A parallel, it may be necessary to provide individual adjustment of grid bias to insure that the plate dissipation of each tube does not exceed the maximum value of 12 watts. This may be accomplished by means of a tapped "C" supply or by means of a variable self-bias resistor for each tube. If self-bias is used, each cathode resistor should be shunted by a condenser large enough to minimize degenerative effects at low audio frequencies. Furthermore, when the tubes are operated in parallel, a noninductive resistance of 10 to 100 ohms should be placed in series with each grid lead, next to the tube socket, to prevent parasitic oscillations.

When two 843's are operated under Class A push-pull conditions, it is usual practice to obtain the grid-bias voltage from a common biasing resistor. In such cases, the value of the resistor is equal to one-half of the value recommended for single tube operation, and the condenser filter is not necessary. If the plate dissipation rating is exceeded under these conditions, the size of the biasing resistor should be increased sufficiently to prevent overloading either tube.

In cases where the input circuit to the 843 is resistance-coupled or impedance-coupled, the resistance in the grid circuit should not be made too high. A resistance value of 0.5 megohm for one 843 is the recommended maximum when self-bias is used. Without self-bias, the grid resistance should not exceed 100,000 ohms.

An output device should be used to transfer audio power efficiently from the 843 to the voice coil of the reproducing unit or to the next audio stage.

As a Class B or Class C radio-frequency amplifier, the 843 may be used as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.

In Class B radio-frequency service, the plate is supplied with unmodulated d-c voltage and the grid is excited by r-f voltage modulated at audio frequency in one of the preceding stages. The plate dissipation should not exceed 15 watts for unmodulated carrier conditions.

Grid bias for the 843 as a Class B r-f amplifier should be obtained from a battery or other d-c source of good regulation. It should not be obtained from a high-resistance supply such as a grid-leak, nor from a rectifier, unless the latter has exceptionally good voltage regulation. For Class C (telegraph) service, grid bias may be obtained from a grid leak of about 25,000 ohms, from a battery, from a rectifier of good regulation, or from a cathode-bias resistor (preferably variable) by-passed with a suitable condenser. The cathode-bias method is especially desirable due to the fact that the grid bias is automatically regulated and that there is little chance of the plate current becoming dangerously high either with or without r-f grid excitation. When the grid-leak method of obtaining grid bias is used, bias is on the tube only when r-f grid excitation is applied. Since grid-bias values are not particularly critical, correct circuit adjustment may be obtained with widely different values. For Class C (telephone) service, fixed bias is recommended because it eliminates the problems of degeneration caused by a-f voltages developed across the biasing system.

The d-c grid current will vary with individual tubes. Under any condition of operation the maximum value should not exceed 7.5 milliamperes.

The 843 can be used at full ratings at frequencies up to 6 megacycles, and at reduced ratings up to 30 megacycles. For operation at the higher frequencies, the plate voltage must be reduced as the frequency is raised so that at 30 megacycles, the plate voltage, plate current, plate dissipation, and d-c grid current will not exceed 50 per cent of the maximum ratings. The r-f grid current, under any conditions should never exceed the maximum rated value. Special attention should be given to adequate ventilation and the maintenance of normal ambient temperatures.

If more r-f power output is required than can be obtained from a single 843, two of these tubes may be used either in parallel or in push-pull. The parallel connection provides approximately twice the power output of a single tube without an increase in exciting voltage, while the push-pull connection gives twice the output but requires twice the r-f excitation voltage; with either connection the grid bias is the same as for a single tube. The push-pull arrangement is advantageous in reducing the shunting effect of the interelectrode capacities, inasmuch as these capacities are in series. This reduction is especially desirable when the tubes are operated at higher frequencies.

When two or more 843's are operated in parallel, a noninductive resistance of 10 to 100 ohms should be placed in series with the grid lead of each tube, close to the socket terminal, to prevent parasitic oscillations.

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GENERAL ELECTRIC

Transmitting Tube GL-813—Installation and Operation

Installation

The base of the 813 fits a special 7-contact transmitting socket which should be mounted to hold the tube in a vertical position with its base either up or down. If it is necessary to place the tube in a horizontal position, the filament-base pins should be placed one vertically above the other so that the plate will be in a vertical plane (on edge).

The bulb becomes very hot during continuous operation of the tube so that free circulation of air around the tube should be provided. The installation of all wires and connections should be made so that they will not be close to or touch the bulb in order to avoid puncture of the glass.

The beam-forming plates of the 813 are connected to a separate base pin. They should always be operated at zero potential with respect to the filament; never positive. When the filament is operated from an a-c supply, the beam-forming plates should be connected to the midpoint of the filament circuit. When the filament is operated from a d-c supply, they should be connected to the negative end of the filament.

The filament of the 813 is of the thoriated-tungsten type. The filament voltage should not vary more than plus or minus 5 per cent from the rated value; otherwise, loss of filament emission may result. It is recommended that if the average number of daily interruptions of the transmitter is greater than 100 per day, the filament voltage should be maintained at 80 per cent of normal during the stand-by periods. If the number of interruptions is less than 100 per day, the filament power may be removed during stand-by periods.

The screen voltage should preferably be obtained from a separate source or from a potentiometer, although it may also be obtained from the plate supply through a series resistor. When the screen voltage is obtained from a separate source, or from a potentiometer, plate voltage should be applied before the screen voltage, or simultaneously with it; otherwise, with voltage on the screen only, the screen current may be large enough to cause excessive screen dissipation. When the screen-resistor method is used, the resistor should have a value sufficient to drop the high voltage to a value which is within the maximum screen-voltage rating given under CHARACTERISTICS. When the series screen resistor is used, it is important that the high-voltage supply switch be opened before the filament circuit is opened and before the r-f excitation is removed; otherwise, full supply voltage will be placed on the screen.

A protective device, such as a high-voltage fuse, should be used to protect both the screen and plate against overloads. When a bleeder resistor of poor regulation or a series resistor is used for obtaining the screen voltage, the protective device should be placed in the common positive high-voltage supply lead. It should remove the high-voltage supply when the d-c plate current reaches a value 50 per cent greater than normal. When the screen voltage is obtained from a separate source or from a bleeder of good regulation, a protective device should also be placed in the screen-supply lead. It should remove the screen voltage when the d-c screen current reaches a value of 50 per cent greater than normal.

Shielding and isolation of the input and the output circuits are necessary for stable operation. If an external shield is used with the 813, it should be designed to enclose the base end of the tube and extend up to a position level with the internal circular shield disk located below the plate. Clearance between the glass bulb and external shield should be at least 1/16 in. The impedance between the screen and filament must be kept low; usually by means of a suitable by-pass condenser. The capacitance of this condenser may be in the order of 0.01 to 0.1 μf. In telephony service when the screen is modulated, a smaller capacitance may be required in order to avoid excessive a-f by-passing. However, if the capacitance is too small, r-f feedback may occur between plate and control grid, depending on the circuit layout, operating frequency, and power gain of the stage. A-f by-passing difficulties can usually be eliminated if the screen by-pass condenser is replaced by a series-tuned circuit to resonate at the operating frequency. The series-tuned circuit presents a high impedance to audio frequencies but a very low impedance to its resonant frequency.

The plate of the 813 shows no color at the maximum plate-dissipation rating for each class of service.

In order that the maximum ratings given under CHARACTERISTICS are not exceeded, changes in electrode voltages due to line-voltage fluctuation, load vari-

ation, and manufacturing variation of the associated apparatus must be determined. An average value of voltage for each electrode should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate and screen voltage. This may be done conveniently by means of a protective resistance of about 1000 ohms in series with the high-voltage supply lead, and a protective resistance of about 2000 ohms in series with the screen lead when a fixed screen-voltage supply is used.

THE RATED PLATE VOLTAGE OF THIS TUBE IS HIGH ENOUGH TO BE DANGEROUS TO THE USER. CARE SHOULD BE TAKEN DURING THE ADJUSTMENT OF CIRCUITS, ESPECIALLY WHEN EXPOSED CIRCUIT PARTS ARE AT HIGH D-C PLATE POTENTIAL.

Operation

In Class B r-f amplifier service, the 813 is supplied with unmodulated d-c plate voltage and the grid is excited by r-f voltage modulated at audio frequency in one of the preceding stages. Under these conditions, the plate dissipation is greatest when the carrier is unmodulated. The screen voltage should be obtained from a separate source or from a potentiometer connected across the plate supply. Driving power is usually negligible and never more than 2 watts. Grid bias may be obtained from a rectifier of good regulation, or from a cathode resistor, suitably by-passed for audio and radio frequencies.

In grid-modulated Class C telephone service, the 813 is supplied with unmodulated r-f grid excitation voltage and with a d-c grid bias which is modulated at audio frequencies. Grid bias should be obtained from an un-by-passed cathode resistor or from a fixed supply. The plate is supplied with unmodulated d-c voltage. The r-f driving power is usually negligible and never more than 2 watts. The audio power required in this service is very small, being sufficient only to meet the peak grid power requirement of the Class C amplifier on the positive crest of the input signal. The actual value is generally never more than 1 watt, dependent on circuit adjustments. The screen voltage should be obtained from a separate source or from a potentiometer connected across the plate supply.

The maximum plate-voltage ratings shown under CHARACTERISTICS for Class B r-f and Class C grid-modulated services may be used provided the plate current for each service is limited so that the respective maximum plate-input rating is not exceeded. Likewise, the maximum plate-current values may be used provided the plate voltage is reduced so that the respective maximum plate-input rating is not exceeded.

In plate-modulated Class C r-f amplifier service, the 813 can be modulated 100 per cent. The screen voltage should preferably be obtained from a fixed supply. The screen voltage must be modulated simultaneously with the plate voltage so that the ratio of screen voltage to plate voltage remains constant. Modulation of a fixed screen-voltage supply can be accomplished either by connecting the screen lead to a separate winding on the modulation transformer or by connecting it through a blocking condenser to a tap on the modulation transformer or choke. When the latter method is used, an a-f choke of suitable impedance for low audio frequencies should be connected in series with the screen-supply lead. Grid bias may be obtained from a grid leak or from a combination of either grid leak and fixed supply, or grid leak and cathode resistor. The combination method is particularly desirable because distortion effects are minimized by bias-supply compensation. Grid bias for Class C service is not particularly critical so that correct adjustment may be obtained with values differing widely from those indicated for this service.

In Class C r-f telegraph service, the 813 may be supplied with screen voltage by any of the methods shown under INSTALLATION. Grid bias may be obtained by any convenient method.

When more radio-frequency power output is required than can be obtained from a single 813; the push-pull or the parallel connection may be used. For example, two tubes connected in push-pull or parallel will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage; the push-pull connection requires twice the r-f excitation voltage necessary to drive a single tube. With either connection, the driving power required is approximately twice that for single-tube operation while the grid bias is the same as that for a single tube. The push-pull arrangement has the advantage of cancelling the even-order harmonics from the output and of simplifying the balancing of high-frequency circuits. If parasitic oscillations occur in the parallel or push-pull circuits, a noninductive resistance of 10 to 100 ohms connected in series with each grid lead as close to the socket terminal as possible, will often prevent the oscillations. With either connection, it is preferable to provide for a separate grid-bias or grid-excitation adjustment in order to balance the grid and plate current.

4-44 (8000)
Filing No. B8850

Supersedes GEH-1103A

GENERAL ELECTRIC

General Installation and Operation of Phanotron Tubes

Description and Notes

These tubes contain a partial atmosphere, usually the vapor pressure of a quantity of mercury, although it may sometimes be an inert gas, or a combination of gas and mercury.

Electrons emitted by the cathode collide with the gas or mercury atoms and produce ionization. Positive ions are attracted toward the cathode and neutralize the normally negative space-charge around the cathode. This action results in a relatively low voltage drop between the anode and the cathode with consequent low loss in the tube.

Installation

MECHANICAL

Phanotrons should be mounted in sockets or supports of good quality with connections of sufficient current-carrying capacity, and should be operated only in a vertical position, as indicated by the outline drawing. A shock-absorbing mounting must be used if the tube is to be subjected to excessive vibration or shock. Since the tube becomes hot during continuous operation, any glass parts, including the seals, should not come in contact with any metallic body; nor be subjected to the drops or spray of any liquid.

ELECTRICAL

The cathode information is given in terms of the normal heating voltage and the approximate current. The cathode should be operated preferably from an a-c source. If alternating current is not available, a d-c source may be used. With each installation it is good practice, where economically justified, to provide a voltmeter connected directly across the filament terminals of the socket.

The cathode must assume operating temperature before electron current is drawn. The delay may be accomplished either by manual or automatic control of the anode circuit. The automatic method is recommended where economically justified, because of the greater protection. The time required for the cathode to come up to normal operating temperature under conditions of good filament circuit regulation is included under ØTechnical Information. In the case of mercury-filled tubes, it is also necessary to bring the condensed-mercury temperature to the minimum operating value. Where the ambient temperature is low and/or where the cathode is quick-heating, this may require a longer time than to bring the cathode to proper temperature.

When tubes with the midtapped filamentary type of cathode are used, the return leads from the anode circuit should be connected to the midtap. If the filament is not midtapped, these leads should be connected to the midtap of the filament transformer winding in the case of alternating current, or to the negative filament terminal in the case of a d-c supply. When an a-c supply is used, it is desirable both with the midtapped filamentary type of cathode and with the type where the filament is not midtapped, to use a filament winding with the filament voltage approximately 90 degrees out of phase with the anode voltage. However, the midtap of the filament transformer must not be used with tubes employing the indirectly heated type of cathode. In tubes of this type, the cathode is connected to one side of the filament, and only corresponding filament prongs should be connected when operating the filaments of two or more tubes in parallel.

An appreciable glow in the tube, when plate voltage is not applied, is an indication that the tube is exposed to radio frequency. Such a condition should be corrected; otherwise the tube life and performance will be adversely affected.

Ø Note: The ratings and characteristics of a particular tube are given under Technical Information on the Description and Rating Sheet for that tube.

THERMAL

When a mercury-vapor phanotron tube is first placed in operation, it is necessary to distribute the mercury properly before anode voltage is applied. This is usually accomplished by applying filament voltage for a period of time sufficient to distill the mercury into the cooling chamber of the tube. The location of the cooling chamber is indicated on the outline drawing by the words "controlling mercury temperature."

This time is generally less than one hour. This procedure need not be repeated unless, during subsequent handling or treatment the mercury is spattered or distilled on the elements or upper portion of the tube.

The design of equipment in which a mercury-vapor tube is used, should be such as to ensure the tube's operating within the condensed-mercury temperature limits over the range of ambient temperatures to be encountered.

When mercury-vapor tubes are subjected to low ambient temperatures or when it is desired to reduce the mercury-heating time (the time required to raise the mercury temperature to operating range), some form of heat-conserving enclosure should be used. This may be provided with thermostatically controlled shutters and/or heaters to bring the condensed-mercury temperature up within the operating range. When heaters are used, they should be located in such a position that the normal condensed-mercury region always remains the coolest portion of the tube enclosure.

When high ambient temperatures are encountered, it may be possible to utilize "chimneylike" enclosures to increase the natural convection cooling. In some cases the use of forced air may be necessary.

Operation

Careful handling and conservative operation will be amply repaid by longer and more uniform tube life. Three of the fundamental limits on the operation of phanotron tubes are the maximum peak inverse anode voltage, maximum instantaneous anode current, and the maximum average anode current.

CATHODE CIRCUIT

The cathode voltage, as indicated by the voltmeter, should not deviate from the rated∅ value by more than five per cent. Filament voltage should be set so that voltage fluctuations give an average value equal to the rated filament voltage. Too low filament voltage may result in very short life or perhaps immediate failure due to loss of emission. Too high voltage will shorten the life of the cathode somewhat.

During stand-by periods the filament should be operated at normal voltage.

ANODE CIRCUIT

The peak inverse voltage applied to the anode should never exceed the rated∅ value. In the usual single-phase circuits, the peak inverse voltage, for sine-wave conditions may be taken as the total anode-transformer secondary voltage (rms value) multiplied by 1.4. The method for calculating the peak inverse voltage for some of the circuits more commonly used with phanotron tubes is shown in drawing "Circuits for hot-cathode mercury-vapor rectifier tubes." The relations between the peak inverse voltage, the direct voltage, and the rms value of alternating voltage depend largely upon the individual characteristics of the rectifier circuit and the power supply. Line surges, keying surges or any other transient or wave-form distortion may raise the actual peak voltage to a value which is higher than that calculated from the sine-wave voltages in the transformer. It should, therefore, be emphasized that the maximum rating of the tube refers to the actual inverse voltage and not to the calculated values. A cathode-ray oscilloscope or a spark gap connected across the tube is useful in determining the actual peak inverse voltage.

The instantaneous anode current experienced is affected largely by the characteristics of the output circuit,

∅ Note: The ratings and characteristics of a particular tube are given under Technical Information on the Description and Rating Sheet for that tube.

including a filter if one is used. In the case of a circuit giving full-wave rectification, if the output circuit is highly inductive with respect to the tube, the instantaneous current may approach the d-c reading in the load circuit. If the output circuit is highly capacitive with respect to the tube, the instantaneous current in the tube may be many times the load current. Analysis of the individual circuit is necessary.

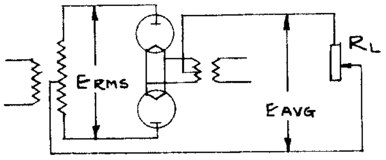
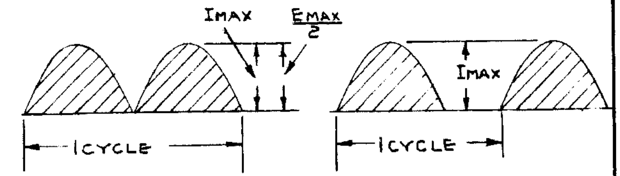
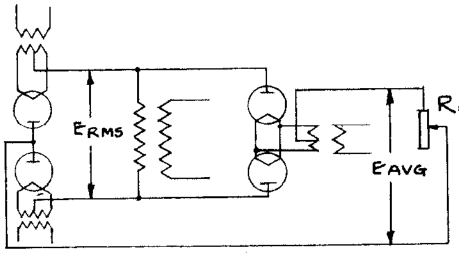
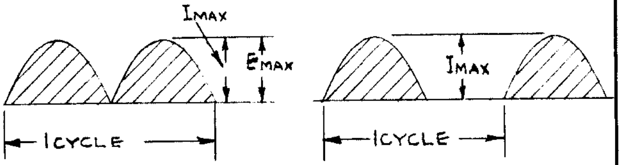
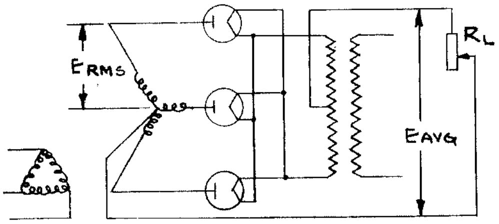
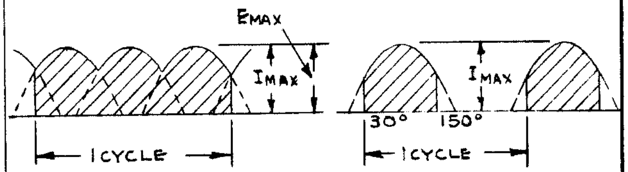
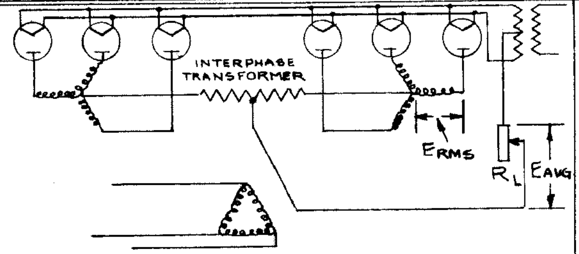
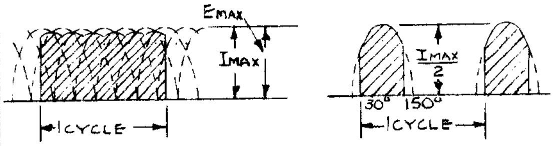
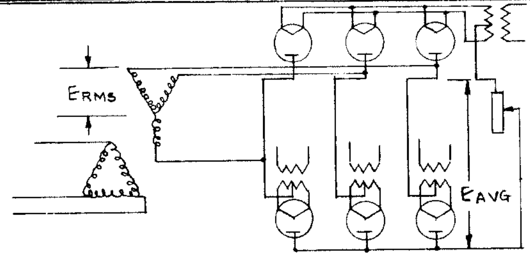
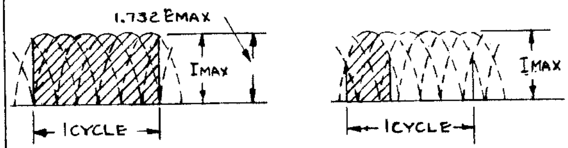
The average anode current must not exceed the rated∅ value. With a steady load this may be read directly on a d-c meter. In the case of fluctuating loads, however, the reading should be averaged over a period not exceeding the time shown under ∅Technical Information.

The maximum surge current is the maximum instantaneous current that can pass through the tube under the most adverse conditions. This rating is intended to form a basis for set design, as it not only limits the currents which might flow during abnormal conditions, but also assures more reliable tube performance than would be obtained with circuits having too low a value of impedance. It does not mean that the tubes can be subjected to short circuit without the probability of a corresponding reduction in life and the possibility of failure. The duration of the surge current shall not be greater than the time shown on the Technical Information.

The voltage drop from anode to cathode is so low that it has little effect on the complete circuit except when the anode voltage used is low. This drop varies with the cathode voltage, with individual tubes, with life, and (in the case of mercury tubes) with the ambient temperature. The range given∅ covers the maximum variations caused by all these factors as long as the tube is operated under the allowable conditions. Rapid changes are rarely encountered.

In installations where uninterrupted service is desired, the tube voltage drop should be checked at regular intervals. Since the tube drop is one criterion of tube condition, failure of tubes may be determined and even anticipated. The end of life will usually be preceded by an acceleration in the rate of increase at the test intervals. Tubes should be withdrawn from use at the beginning of this stage for maximum reliability of the installation.

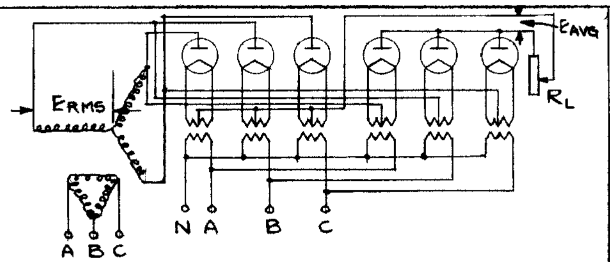
NOTICE: GAS- OR VAPOR-FILLED TUBES, BECAUSE OF THEIR CONSTANT DROP PROPERTIES, REQUIRE SUFFICIENT PROTECTIVE RESISTANCE IN THE ANODE CIRCUIT TO LIMIT THE CURRENT TO THE RATED VALUE.

NO	FIGURE	WAVE FORM (LOAD CURRENT / TUBE CURRENT)
1	 BIPHASE HALF-WAVE TWO ANODES	
2	 BIPHASE FULL-WAVE THREE ANODES	
3	 THREE-PHASE HALF-WAVE THREE ANODES	
4	 DOUBLE-THREE-PHASE HALF-WAVE WITH INTERPHASE TRANSFORMER SIX ANODES	
5	 THREE-PHASE FULL-WAVE SIX ANODES	

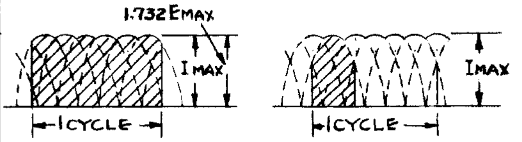
CIRCUITS FOR RECTIFIER TUBES

	FIGURE	WAVE FORM

6



THREE-PHASE FULL-WAVE QUADRATURE EXCITATION, Δ-Y MAIN TRANSFORMER



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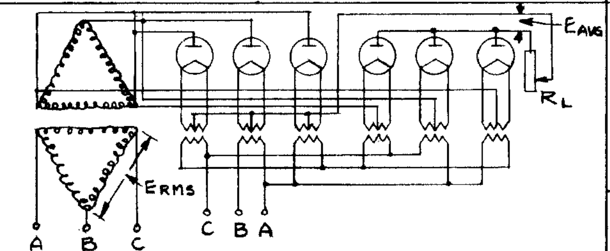
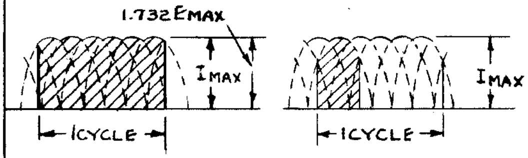


THREE-PHASE FULL-WAVE QUADRATURE EXCITATION Δ-Δ MAIN TRANSFORMER



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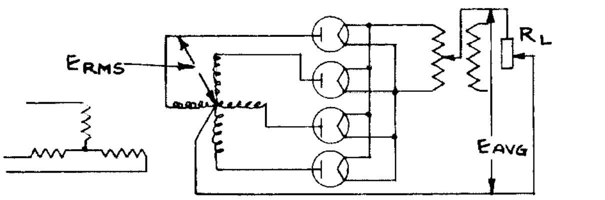
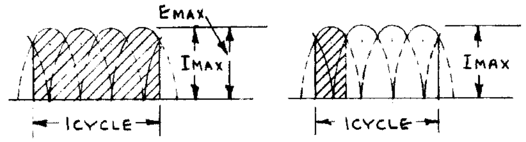


FOUR-PHASE HALF-WAVE FOUR ANODES



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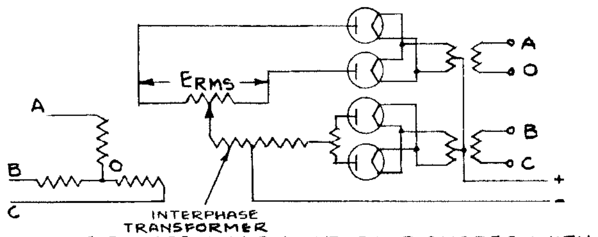
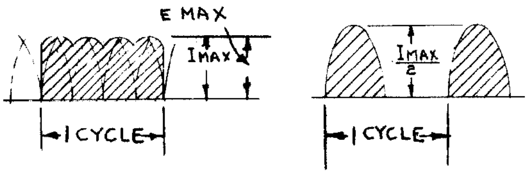
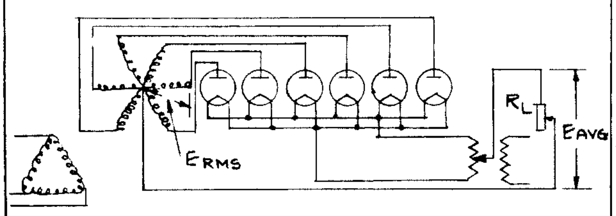


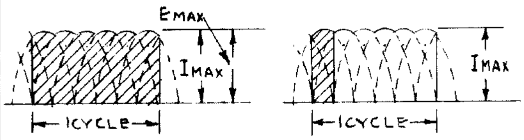
DOUBLE-BIPHASE HALF-WAVE FOUR ANODES WITH QUADRATURE EXCITATION



10



SIX-PHASE HALF-WAVE SIX ANODES



CIRCUITS FOR RECTIFIER TUBES F

CONTINUED FROM SHEET #2

USEFUL RATIOS

FIG NO	TUBE I(AVG) / LOAD I(AVG)	E AVG	E INVERSE	I AVG
1	0.500	0.318 EMAX 0.450 ERMS	EMAX 3.140 EAVG	0.636 IMAX
2	0.500	0.636 EMAX 0.900 ERMS	EMAX 1.570 EAVG	0.636 IMAX
3	0.333	0.827 EMAX 1.170 ERMS	$\sqrt{3}$ EMAX 2.090 EAVG	0.827 IMAX
4	0.167	0.827 EMAX 1.170 ERMS	$\sqrt{3}$ EMAX 2.090 EAVG	0.827 IMAX
5	0.333	1.650 EMAX 2.340 ERMS	$\sqrt{3}$ EMAX 1.050 EAVG	0.955 IMAX
6	0.333	1.650 EMAX 2.340 ERMS	$\sqrt{3}$ EMAX 1.050 EAVG	0.955 IMAX
7	0.333	0.955 EMAX 1.340 ERMS	EMAX 1.050 EAVG	0.955 IMAX
8	0.250	0.900 EMAX 1.274 ERMS	2.220 EAVG	0.900 IMAX
9	0.250	0.318 EMAX 0.450 ERMS	3.140 EAVG	0.318 IMAX
10	0.167	0.955 EMAX 1.350 ERMS	2.090 EAVG	0.955 IMAX

CIRCUITS FOR RECTIFIER TUBES

Service Information

Complete instructions are packed with each shipment of tubes. Additional copies can be secured from the nearest office of the General Electric Company.

General Electric tubes are warranted to be of the kind and quality described in the manufacturers' specifications. Before leaving the factory, each tube is subjected to rigid tests and inspections. Performance will depend, to a large extent, upon the application, and upon the care with which the tubes are handled. In case of doubt as to proper operating conditions, information should be secured from the General Electric Office through which the purchase was made.

INTRODUCTION

This service sheet is furnished for the convenience of the customer in applying for adjustment if the quality of the tube does not meet the specification and warranty under which the tube was sold. In order that prompt action can be taken the information required in the service report form should be supplied in complete detail.

INITIAL TEST

To assure satisfactory operation, it is recommended that each tube be tested upon receipt by the customer, preferably in equipment of the same type and rating as that in which it is to be used. Such a procedure will assure that tubes damaged in transportation are not carried in stock. If spare tubes are stocked for long periods, a check test should be made at least every three months. The conditions of test and operation shall not be more severe than the conditions described in the manufacturers' specifications and instructions.

TRANSPORTATION CLAIMS

Should the package be received in a damaged condition, observance of the procedure described on the tag affixed to the container will enable the General Electric Company to assist the customer in filing a claim for tubes damaged in transit.

RETURN PROCEDURE

If any failure of the tube to comply with the specifications or warranties under which the tube was purchased occurs, the purchaser shall

1. Notify the nearest sales office of the General Electric Company. The manufacturer's office will advise the purchaser regarding the correct packing instructions and shipping procedure for returning tubes believed to be defective.

2. Tubes returned for credit adjustment should be packed as carefully as when originally received, for damage sustained in return shipment will make a thorough examination impossible.

If more than one tube is involved, the tubes should be identified by some permanent marking, such as a securely tied tag, which will enable them to be associated with this service report.

PERMISSION FOR DISMANTLING

In returning a vacuum tube for test and examination, the customer gives permission to the General Electric Company to break the glass bulb and to dissect the structure of the tube in case such procedure is considered necessary for complete examination.

Service Report Form - NEMA Standard

Tube Type No. ______________ Serial No. ______________

Date Received ______________ Date First Tested ______________

Date Placed in Service ______________ Date Inoperative ______________

Hours of Cathode Operation ______________ Hours of Anode Operation ______________

If Stand-by Operation is Used Show Filament Voltage for Stand-by Condition ______________

Nature of Defect ______________

____

Describe any unusual phenomena which took place just previous to or at time of failure

____

____

Code No. and maker of equipment in which tube was used ______________

____

Was tube used in experimental equipment or experimental adjustment ______________

____

Were all other circuit elements operating properly at time of tube failure ______________

____

PURCHASER ______________

ADDRESS ______________

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

10-42(25M)
Filing No. 8850

Supersedes GEH-977D

PRINTED IN U.S.A.

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

General Installation and Operation of Transmitting Tubes

Installation

MECHANICAL

Mountings must be of good quality and should be so installed as to minimize danger from impact. If the set is subject to vibration, a shock-absorbing suspension must be employed.

COOLING

All apparatus should be arranged to allow free circulation of air around the pliotron. The bulb becomes very hot during operation and, therefore, should neither come in contact with any metallic object nor be subjected to drops or spray of liquid.

Sets using more than one tube should provide adequate spacing between tubes so that adjacent portions of the bulbs do not operate appreciably hotter than the other sections.

ELECTRICAL

To avoid danger of corona discharge, all wires and connections should be made to allow several inches of free space around the pliotron. For tubes using a metal base, the metal shell must not be connected to any part of the circuit.

The filament should be operated preferably from an a-c source, although a d-c supply may be used. The filament voltmeter should be connected to indicate the voltage at the filament terminals. The filament supply should be designed to allow operation at rated filament voltage. The filament transformer shall have good regulation and should be designed for at least thirty per cent above rated filament wattage.

Thoriated-tungsten filaments should be operated at eighty per cent of normal filament voltage during stand-by periods of less than two hours and shut down entirely for longer periods. However, for small tubes of less than 250 watts plate dissipation rating the filament voltage may be removed for stand-by periods greater than 15 minutes. There should be no reduction of filament voltage for periods of less than five minutes. The filament voltage may be reduced to eighty per cent during periods greater than five minutes if desired.

Oxide-coated filaments or cathode heaters should be operated at normal filament voltage during stand-by periods. If the stand-by periods exceed two hours the filament current may be shut off.

Overheating by severe overload may decrease filament emission. Unless the overload has liberated a large amount of gas, the activity of the filament usually can be restored by operating the filament at rated voltage for ten minutes or more with no voltage on the plate or grid. This process may be accelerated by increasing the filament voltage to 20 per cent above the †normal value (not higher) for a few minutes.

The grid-circuit and plate-circuit return leads should be connected to the center tap of the filament-transformer secondary. When d-c filament excitation is used, the return leads from the grid and plate circuits should be connected to the negative filament terminal.

The circuits should be arranged to prevent parasitic oscillations so that the tube will not be subjected to excessive voltages and current.

An ammeter in the plate circuit of each tube should be connected so that the direct-plate current may be checked regularly.

The plate circuit should be provided with a protective device such as a fuse or relay in order to prevent overheating caused by improper circuit adjustments or overloading. This device should remove the plate voltage instantly if the direct-plate current reaches a value 50 per cent above †normal.

In rating pliotrons, certain values are given as maximum; that is, the values

†Note: The ratings and characteristics of a particular pliotron are given on the Description and Rating Sheet for that tube.

beyond which it is unsafe to go from the viewpoint of life and performance. In order not to exceed the †maximum ratings, changes in plate and filament voltage caused by line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus must be determined. Then, an average value of plate voltage should be chosen so that under the usual operating conditions the maximum ratings will not be exceeded.

IN TRYING OUT A NEW CIRCUIT OR WHEN ADJUSTMENTS ARE BEING MADE, THE PLATE VOLTAGE SHOULD BE REDUCED IN ORDER TO PREVENT DAMAGE TO THE PLIOTRON OR ASSOCIATED APPARATUS IN CASE THE ADJUSTMENTS ARE INCORRECT.

Operation

GENERAL

Maximum ratings and typical operating conditions for each recommended class of service are given on the Description and Rating Sheet covering the individual type of pliotron. The typical values given must not be considered as ratings, because the tube may be used at any suitable conditions within the maximum ratings.

CLASS A AUDIO-FREQUENCY AMPLIFIER OR MODULATOR.

Grid bias for this type of service may be obtained from a separate voltage source or by means of a self-biasing resistor shunted by a filter network to avoid degenerative effects at the low audio-frequencies. When several tubes are operated in parallel, it is necessary to make provision for individual adjustment of grid bias to insure that the plate dissipation of any tube does not exceed the †maximum value. This may be accomplished by means of a tapped "C" battery or, if self bias is used, by means of a variable cathode resistor for each tube. When the self-biasing method is used, separate filament supplies are necessary for each tube.

An output device such as a choke or transformer should be used to transfer power efficiently from the pliotron to the load.

CLASS B AUDIO-FREQUENCY POWER AMPLIFIER OR MODULATOR

In this type of service two tubes are used in a "balanced" circuit, each tube conducting only half the time. The plate loss becomes maximum at a signal slightly less than 1, depending on the circuit conditions, and therefore the plate dissipation must be limited so that at this value of sustained signal, the plate loss will not exceed the maximum rating.

The input transformer should be designed to give good frequency response when operated into an open circuit, such as that represented by the grid circuit of the Class B stage when the signal amplitude is small. It should be designed also to handle the required input power for maximum signal conditions.

The output transformer should be designed so that the resistance presented by the load is reflected as the proper plate-to-plate loading in the Class B stage. For example, if the load is a modulated Class C amplifier operating at 2000 volts and 500 milliamperes, the ratio of the output transformer to provide a plate-to-plate loading of 10,000 ohms would be $\sqrt{10000 \div 4000}$, or 1.58 to 1, step-down. The transformer should be designed with a core large enough to avoid saturation effects, which would impair the quality of the output. If the secondary is to carry the direct plate current of the modulated amplifier, the core should be made larger and should include an air gap.

CLASS B RADIO-FREQUENCY AMPLIFIER

In Class B radio-frequency service, the plate is supplied with unmodulated direct voltage, and the grid is excited by modulated r-f voltage. It is important to note that in this service the plate dissipation is greatest when the carrier is unmodulated. Therefore, the circuit should be adjusted so that, without modulation, the plate loss will not exceed the †maximum rating.

Grid bias for Class B a-f or r-f service should be obtained from a battery or other d-c source of good regulation. It should not be obtained from a high-resistance supply such as a grid leak.

CLASS C RADIO-FREQUENCY POWER AMPLIFIER -- PLATE MODULATED

In this type of service, the plate supply voltage is modulated so that the tube output is modulated radio frequency. Assuming a value, P, of plate input to be modulated, the amount of audio-frequency

†Note: The ratings and characteristics of a particular pliotron are given on the Description and Rating Sheet for that tube.

power to be supplied is equal to $\frac{m^2P}{2}$, where m is the modulation factor.

The maximum ratings and typical operating conditions given in the †Technical Information are such that a modulation factor up to 1.0 may be used. When a lower value of modulation is used, the plate dissipation allowed may be increased, but should be limited so that with the modulation sustained at its peak value, m, the plate loss will not exceed a value $\frac{3}{2+m^2}$ times the plate dissipation rating.

Grid bias for this service may be obtained from a grid leak or from a combination of grid leak and generator, rectifier, or cathode-bias resistor, suitably by-passed for audio and radio frequencies. The combination method is desirable because distortion effects may be minimized.

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR

In telegraph service, the plate input power is keyed, i.e., is on and off alternately in accordance with the characters of some code. During the "key-down" periods, the tube functions as an unmodulated radio-frequency power amplifier. The tube may be used also as an amplifier or oscillator without keying. In both types of service, the ratings given are for "key-down" conditions.

Certain methods of modulation may be applied to this class of service provided the modulation is essentially negative and the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

Grid bias for Class C service may be obtained from a grid leak, from a battery, from a rectifier of good regulation, or from a self-biasing resistor by-passed with a suitable capacitor. With the grid-leak method, the grid excitation must not be removed without also removing the plate voltage. Grid-bias values are not particularly critical, and correct circuit adjustment may be obtained with widely different values.

†Note:. The ratings and characteristics of a particular pliotron are given on the Description and Rating Sheet for that tube.

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

Supersedes GEH-980H

·44 (100M)
'iling No. 8850

PRINTED IN U.S.A.

GENERAL ELECTRIC

General Installation and Operation of Kenotron Tubes

Installation

MECHANICAL

The handling of a kenotron in transportation and storage requires great care since the tube may be permanently damaged if subjected to shock. Each tube is suspended within its shipping carton so that it will not come in contact with the sides of the carton during shipment. The tube should be stored in the carton and should be protected from moisture and extreme temperature changes. Furthermore, while the tube is being handled it should be kept in a vertical position with the cathode end down. Under no circumstances should crated tubes be piled on top of one another.

The kenotron should be installed in a vertical position with the cathode base down.

In installations where a nonrigid anode connection is used, reasonable flexibility must be provided to prevent placing a strain on the cathode base. Since the bulb becomes hot during continuous operation, it should not come in contact with any metallic body, nor be subjected to the drops or spray of any liquid.

The accumulation of dust and metallic particles on the outer surface of the glass walls will increase the leakage over this surface. As this may result in tube failure from arc-over, periodic cleaning of these surfaces should be maintained.

When a kenotron is operated at voltages above 75 kv peak inverse, harmful x-rays may be generated. Adequate protection against these x-rays should be provided.

COOLING

Free circulation of cool air around the glass bulb should be maintained. High-temperature air from other apparatus should be prevented from circulating around the tubes. If desired the tubes may be immersed in a tank of oil with the transformers.

----

*Note: The ratings and characteristics of a particular tube are given under Technical Information on the Description and Rating Sheet for that tube.

ELECTRICAL

Filament power should be supplied from a filament lighting transformer insulated for the proper voltage. This transformer should be provided with a secondary midtap for the plate circuit return lead. The filament excitation supply must be provided with suitable resistors or other regulating devices to apply the power to the filament gradually and to adjust it accurately during operation. The filament voltage should be measured directly at the filament terminals.

The high initial rush of current through the filament when the switch is first closed should be limited by the use of some form of filament starter. The proper use of the filament regulating devices will prevent this initial rush of current from destroying the filament. In any case, the current through the filament should never, even instantaneously, exceed twice the *rated value.

When the apparatus in which the tube is used is to be idle for periods not exceeding two hours, voltage should be maintained on the filament. However, if desired, provision may be made to reduce the filament voltage to approximately 80 per cent of the *rated value during "standbys." Where stand-by periods exceed two hours the filament voltage may be removed.

The plate circuit should be provided with a time-delay relay which will prevent application of plate voltage until the filament has reached normal operating temperature.

Automatic protective devices should be installed to prevent over-plate-voltage, over-plate-current, or under-filament-voltage conditions.

In the case of multi-phase installations, the plate transformer is usually designed for rectifier use. In the case of a double Y rectifier, the use of an inter-phase transformer is recommended. The cathode base should not be connected to ground or to any other part of the circuit.

The installation of all wires and connections should be made so that they do not lie on or close to the glass of the kenotron. An air space of approximately the length of the tube should be main-

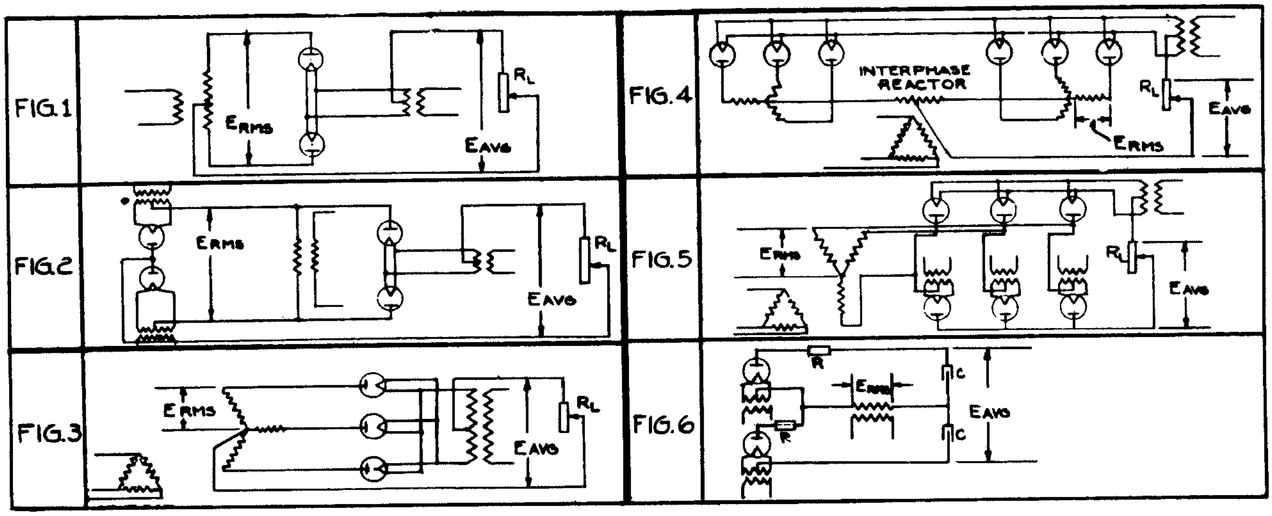


Fig	Circuit	E average	E inverse	I average
1	Single-phase, Full-wave	0.318 Emax 0.450 Erms	Emax 3.14 Eavg	0.636 Imax
2	Single-phase, Full-wave	0.636 Emax 0.900 Erms	Emax 1.57 Eavg	0.636 Imax
3	Three-phase, Half-wave	0.827 Emax 1.170 Erms	$\sqrt{3}$ Emax 2.09 Eavg	0.827 Imax
4	Three-phase, Double-Y Parallel	0.827 Emax 1.170 Erms	1.732 Emax 2.09 Eavg	1.91 Imax
5	Three-phase, Full-wave	1.65 Emax 2.34 Erms	$\sqrt{3}$ Emax 1.05 Eavg	0.955 Imax
6	Voltage Doubler	2.83 Erms No Load Conditions	Eavg No Load Conditions	

Note for Fig 6:

Output voltage depends on load and circuit regulation. The circuit must be designed so that the tube ratings are not exceeded. Particularly, values of C and R must be chosen to limit charging current so that peak current rating of tube will not be exceeded.

tained between the bulb and any metallic body during operation. Otherwise, corona discharge may develop and result in puncture of the glass bulb.

Operation

Ordinary care in handling and provision for the necessary operating conditions peculiar to the kenotron will minimize accidental damage to the tube.

The maximum values given in the *rating of kenotrons are the values beyond which it is unsafe to operate, if the maximum life and performance are desired. For example, the maximum operating plate voltage can be obtained from the Technical Information and the amount of voltage fluctuation, due to line, load, and manufacturing variation in the apparatus must be determined or estimated. An average value of plate voltage must be used which, under normal operating variations, does not exceed the maximum rated value.

With regard to power, the ratings given on the Technical Information prescribe two limiting operating conditions. The first is a maximum peak inverse voltage which should not exceed a certain safe value determined by the insulation between electrodes of the tube. The maximum peak

inverse voltage is the highest voltage that the tube will insulate on the half cycle when no current is passing through the tube. As any and all of the following factors - line surges, circuit capacitance, wave form distortion, and the maximum peak voltage of the applied alternating voltage - may increase this inverse voltage to a value higher than the rated maximum peak voltage, the kenotron should never be used at the maximum rated voltages unless measurements, either by oscillograph or sphere gap, have indicated that at no time does the peak voltage across the tube exceed this value.

The second limiting value is the power dissipation of the plate which is determined by the d-c load current almost regardless of the voltage across the load. The maximum peak plate current is the greatest instantaneous current that may be drawn from a kenotron on the half cycle during which the plate of the tube is positive. As the design of the circuit, especially the amount of capacitance in the circuit, is a major factor in determining the amount of current available in a given rectifier, oscillograph measurements of this current should be made if any doubt exists as to the magnitude. If the kenotron is to be operated at full *peak current rating, it will be necessary to maintain exactly the rated filament voltage. If the peak current to be drawn is less than the full rated value, the allowable filament voltage regulation increases as the value of the peak current decreases.

The following tabulation shows the reduction of the maximum peak current with reduced filament voltage:

Filament Voltage % of Rated	Maximum Peak Current % of Rated
100	100
95	65
90	40
85	25
80	10

Excessive anode temperature is an indication of abnormal voltage drop in the tube and is usually caused by low filament temperature. Filament voltage greater than the rated value, while increasing the maximum peak current available, will result in decreased tube life.

The regulation of the filament supply voltage should be such that the minimum filament voltage will not be less than that recommended in the tabulation for the peak current demand.

The filament should be operated at constant voltage rather than at constant current and should always be allowed to reach normal operating temperature before the plate voltage is applied.

Six basic circuits in which the kenotron may be used are shown schematically on Fig. 1. The values given are ideal conditions which usually cannot be obtained in actual installations because of poor regulation and other abnormal supply line conditions. Therefore, these factors must be considered and subtracted from the supply voltage to the tubes in order that the maximum voltage rating is not exceeded.

In parallel operation the filaments of all tubes must be supplied from a common source and the voltage of this source must be adjusted to the rated value of the individual tube when all tubes are lighted.

In series circuits, separate filament transformers must be provided. Also provision must be made for equalizing the voltage drop of each tube in the series.

When any kenotron, except the FP-85, is first placed in operation the following procedure should be observed. The tube should be operated without plate voltage for five minutes at rated filament voltage. After this initial preheating schedule, the plate voltage can be applied. Start with not more than one-half the usual operating voltage and then carefully increase it in steps over a period of approximately 15 minutes to the desired value. The tube should then be operated under the normal load conditions for a period of approximately 15 minutes or more. If the plate voltage is varied by taps on the primary, the plate-circuit relay should be open when the taps are changed in order to avoid dangerous surges. It is recommended that every three months spare tubes be given the preheating and initial operation schedule as discussed above. This will insure that only good tubes are carried in stock.

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SCHENECTADY, N.Y.

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GENERAL ELECTRIC

Transmitting Tube GL-1623 - - Installation and Operation

INSTALLATION

The base of the 1623 fits the standard 4-contact socket such as the Type UR-542A. The socket should be installed to hold the tube in a vertical position with the base down. If it is necessary to place the tube in a horizontal position, the filament base pins should be placed one vertically above the other so that the filament will be in a vertical plane (on edge). The plate lead is brought out to a cap at the top of the tube.

The bulb becomes very hot during continuous operation of the tube. Care should be taken, therefore, that the bulb is not subjected to the drops or spray of liquid.

The filament of the 1623 is of the thoriated-tungsten type. The filament voltage should not vary more than plus or minus 5 per cent from the rated value; otherwise, a loss of filament emission may result. When the apparatus in which the tube is used is idle for short periods of time, the filament should be maintained at its rated voltage during the "stand-bys."

The plate shows no color at the maximum plate-dissipation rating for each class of service.

Overheating of the 1623 by severe overload may decrease filament emission. Filament activity can sometimes be restored by operating the filament at rated voltage for ten minutes or more with no voltage on the plate or grid. The process may be accelerated by raising the filament voltage to 7.5 volts (not higher) for a few minutes. The positive high-voltage supply lead of the 1623 should be provided with a protective device, such as a high-voltage fuse, to prevent the tube from drawing excessive plate current. This device should remove the high-voltage supply when the d-c plate current reaches a value 50 per cent greater than normal.

In order that the maximum ratings given under CHARACTERISTICS will not be exceeded, changes in plate and filament voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus, must be determined. An average value of plate and filament voltage should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate voltage. This may be done conveniently by means of a resistance of about 4000 ohms in series with the high-voltage plate lead. The rated plate voltage of this tube is high enough to be dangerous to the user. Care should be taken during the adjustment of circuits, especially when the exposed circuit parts are at high d-c plate potential.

OPERATION

In Class B modulator or a-f amplifier service, two 1623's are used in a balanced circuit, each tube amplifying half the time. The input transformer should be designed to give good frequency response when operated into an open circuit, such as that represented by the grid circuit of the Class B stage when the signal amplitude is small. It should also be designed to handle the required input power for a strong signal. The output transformer should be designed so that the resistance load presented by the modulated Class C amplifier is reflected as the recommended plate-to-plate load in the Class B a-f stage. Grid bias may be obtained from a battery or other d-c source of good regulation. It should not be obtained from a high-resistance supply such as a grid leak, nor from a rectifier, unless the latter has exceptionally good voltage regulation.

In Class B r-f service, the 1623 is supplied with unmodulated d-c plate voltage. The grid is excited by r-f voltage modulated at audio frequency in one of the preceding stages. The plate dissipation is greatest when the carrier is unmodulated. Grid bias may be obtained from a battery, from a rectifier

of good regulation, or from a cathode resistor, suitably by-passed for audio and radio frequencies. The maximum plate voltage values may be used provided the plate current is limited so that the maximum plate-input rating is not exceeded. Likewise, the maximum plate-current values may be used provided the plate voltage is limited so that the maximum plate-input rating is not exceeded.

In plate-modulated Class C r-f service, the 1623 may be supplied with grid bias from a grid leak, or from a suitable combination of either grid leak and fixed supply, or from a grid leak and cathode-bias resistor. The cathode resistor should be suitably by-passed for audio and radio frequencies. The combination method of grid leak and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion effects by bias-supply compensation. Grid-bias voltage is not particularly critical so that correct adjustment may be obtained with values differing widely from those indicated for this service.

In Class C r-f telegraph service, the 1623 may be supplied with grid bias by any convenient method.

The 1623 can be operated at maximum ratings in all classes of service at frequencies as high as 60 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown under CHARACTERISTICS). The tabulation* shows the highest percentage of maximum plate voltage and power input that can be used up to 115 mc for the various classes of service.

When more radio-frequency power output is required than can be obtained from a single 1623, the push-pull or the parallel connection may be used. For example, two tubes connected in push-pull or parallel will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage; the push-pull connection requires twice the r-f excitation voltage necessary to drive a single tube. With either connection, the driving power required is approximately twice that for single-tube operation while the grid bias is the same as that for a single tube. The push-pull arrangement has the advantage of cancelling the even-order harmonics from the output and of simplifying the balancing of high-frequency circuits. If parasitic oscillations occur in the parallel or push-pull circuits, a noninductive resistance of 10 to 100 ohms connected in series with each grid lead as close to the socket terminal as possible, will often prevent the oscillations.

* See Description and Rating Sheet.

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GENERAL ELECTRIC

Transmitting Tube GL-812 - - Installation and Operation

Installation

The base of the 812 fits the standard 4-contact socket such as the Type UR-542A. The socket should be installed to hold the tube in a vertical position with the base down. If it is necessary to place the tube in a horizontal position, the socket should be mounted with the filament-pin openings one vertically above the other so that the plate will be in a vertical plane (on edge). The plate lead of the tube is connected to a metal cap at the top of the bulb.

The bulb becomes very hot during continuous operation. Therefore, free circulation of air around the tube should be provided.

The filament of the 812 is of the thoriated-tungsten type. The filament voltage should not vary more than ±5 per cent from the rated value.

When the tube is used in intermittent service, the filament voltage may be removed for stand-by periods greater than fifteen minutes. There should be no reduction of filament voltage for periods of less than five minutes. The filament voltage may be reduced to eighty per cent during periods greater than five minutes if desired.

The plate of the 812 shows a dull red color at its maximum plate-dissipation ratings of 50 to 55 watts; it shows no color at a plate dissipation rating of 40 watts.

Overheating of the 812 by severe overload may decrease its filament emission. The filament activity can sometimes be restored by operating the filament at rated voltage for ten minutes or more with no voltage on the plate or grid. This process may be accelerated by raising the filament voltage to 7.5 volts (not higher) for a few minutes. The positive high-voltage supply lead should be provided with a protective device, such as a high-voltage fuse. This device should instantly remove the plate voltage when the d-c plate current reaches a value 50 per cent greater than normal.

In order that the maximum ratings given under CHARACTERISTICS will not be exceeded, changes in plate and filament voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus must be determined. An average value of plate and filament voltage should then be chosen so that under the usual voltage variations the maximum rated voltage will not be exceeded.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced in order to prevent damage to the tube or associated apparatus in case the circuit adjustments are incorrect. It is advisable to use a protective resistance of about 10,000 ohms in series with the plate lead during such adjustments. The rated plate voltage of this tube is high enough to be dangerous to the user. Care should be taken during the adjustment of circuits, especially when the exposed circuit parts are at the high d-c plate potential.

Operation

In Class B modulator or audio-frequency service, two 812's are used in a balanced circuit, each tube amplifying half the time. The input transformer should be designed to give good frequency response when operated into an open circuit, such as that represented by the grid circuit of the Class B stage when the signal amplitude is small. It should also be designed to handle the required input power for a strong signal. The output transformer should be designed so that the resistance load presented by the modulated Class C amplifier is reflected as the recommended plate-to-plate load in the Class B a-f stage. Grid bias should be obtained from a battery or other d-c source of good regulation.

In Class B r-f service, the 812 may be supplied with bias from a battery, from a rectifier of good regulation, or from a cathode resistor, suitably by-

passed for both audio and radio frequencies.

In plate-modulated Class C r-f service, the 812 may be supplied with grid bias from a grid leak, or from a combination of grid leak and fixed supply, or grid leak and cathode resistor. The cathode resistor should be suitably by-passed for both audio frequency and radio frequency. The combination method of grid leak and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation.

In Class C r-f telegraph service, the 812 may be supplied with grid bias by any convenient method. When the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to maintain the plate current at a safe value. For example, if the 812 is operated at the maximum rated plate voltage of 1500 volts (ICAS), a fixed bias of at least -45 volts should be used.

In self-rectifying oscillator service, the 812 is supplied with a-c plate voltage. Grid bias may be obtained by any convenient method; a grid resistor is commonly used because of its convenience and because the bias is automatically adjusted as the load on the circuit varies.

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

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GENERAL ELECTRIC

Transmitting Tube GL-811 - - Installation and Operation

Installation

The base of the 811 fits a standard four-contact socket such as the Type UR-542A. The socket should be installed to hold the tube in a vertical position with the base down. If it is necessary to place the tube in a horizontal position, the tube should be mounted with the plate in a vertical plane (on edge). The plate lead of the tube is connected to a cap at the top of the bulb.

The bulb becomes very hot during continuous operation so that free circulation of air around the tube should be provided.

The filament of the 811 is of the thoriated-tungsten type. The filament voltage should not vary more than plus or minus 5 per cent from the rated value; otherwise, a loss of filament emission may result. The filament voltage may be removed for stand-by periods greater than fifteen minutes. There should be no reduction of filament voltage for periods of less than five minutes. Filament voltage may be reduced to eighty per cent during periods greater than five minutes if desired. The filament of the 811 should be operated at constant voltage rather than constant current and should be allowed to reach normal operating temperature before other voltages are applied.

The plate of the 811 shows a dull red color at its maximum plate-dissipation ratings of 50 to 55 watts; it shows no color at a plate dissipation of 40 watts.

Overheating of the 811 by severe overload may decrease its filament emission. The filament activity can sometimes be restored by operating the filament at rated voltage for ten minutes or more with no voltage on the plate or grid. This process may be accelerated by raising the filament voltage to 7.5 volts (not higher) for a few minutes. The plate circuit should be provided with a protective device, such as a high-voltage fuse. This device should instantly remove the plate voltage when the d-c plate current reaches a value of 50 per cent greater than normal.

In order that the maximum ratings will not be exceeded, changes in plate and filament voltages due to line-voltage fluctuation load variation, and manufacturing variation of the associated apparatus must be determined. An average value of plate and filament voltage should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced in order to prevent damage to the tube or associated apparatus in case the circuit adjustments are incorrect. It is advisable to use a protective resistance of about 1000 ohms in series with the plate lead during such adjustments. The rated plate voltage of this tube is high enough to be dangerous to the user. Care should be taken during the adjustment of circuits, especially when the exposed circuit parts are at high d-c plate potential.

Operation

In Class B modulator or audio-frequency service, two 811's are used in a balanced circuit, each tube amplifying half the time. The input transformer should be designed to give good frequency response when operated into an open circuit, such as that represented by the grid circuit of the Class B stage when the signal amplitude is small. It should also be designed to handle the required input power for a strong signal. The output transformer should be designed so that the resistance load presented by the modulated Class C amplifier is reflected as the recommended plate-to-plate load in the Class B a-f stage. Grid bias should be obtained from a battery or other d-c source of good regulation.

In Class B r-f service, the 811 may be supplied with bias from a battery, from a rectifier of good regulation, or from a cathode resistor, suitably bypassed for both audio and radio frequencies.

In plate-modulated Class C r-f service, the 811 may be supplied with grid bias from a grid leak, or from a

combination of grid leak and fixed supply, or grid leak and cathode resistor. The cathode resistor should be suitably by-passed for both audio-frequency and radio-frequency. The combination method of grid leak and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation.

In Class C r-f telegraph service, the 811 may be supplied with grid bias by any convenient method. Grid-leak bias, however, is particularly suitable for this tube. Even when the grid excitation is removed under maximum plate voltage conditions, the zero-bias plate current remains at a safe value. Therefore, it is practical to use the 811 with grid-leak bias alone in the final amplifier or in a preceding stage of a transmitter designed for break-in operation and oscillator keying.

The 811 can be operated at maximum ratings in all classes of service at frequencies as high as 60 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown under Technical Information). The tabulation* shows the highest percentage of maximum plate voltage and power input that can be used up to 100 mc for the various services.

* See Description and Rating Sheet

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GENERAL ELECTRIC

Transmitting Tube GL-810 - - Installation and Operation

Installation

The base of the 810 fits the standard transmitting, 4-contact socket such as the Type UT-541A. The socket should be installed so that the tube will operate in a vertical position with the base down. If it is necessary to place the tube in a horizontal position, the tube should be mounted with the plate in a vertical plane (on edge).

The bulb becomes very hot during continuous operation of the tube so that free circulation of air around the tube should be provided.

The filament of the 810 is of the thoriated-tungsten type. The filament voltage should not vary more than ± five per cent from the rated value; otherwise, loss of filament emission may result. It is recommended that, in intermittent service where the average number of daily transmissions is greater than 100, the filament be maintained at 80 per cent of normal voltage during stand-by periods. If the number of transmissions is less than 100 per day, the filament power should be removed during stand-by periods.

Overheating of the 810 by severe overload may decrease its filament emission. Filament activity can sometimes be restored by operating the filament at rated voltage for ten minutes or more without voltage on the plate or grid. The process may be accelerated by raising the voltage to 12 volts (not higher) for a few minutes. The plate circuit should be provided with a protective device such as a high-voltage fuse. This device should instantly remove the plate voltage when the d-c plate current reaches a value 50 per cent greater than normal.

The plate of the 810 shows only a barely perceptible red color at the maximum plate-dissipation rating for each service.

In order that the maximum ratings given under CHARACTERISTICS will not be exceeded, changes in plate and filament voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus, must be determined. An average value of plate and filament voltage should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate voltage. This may be done conveniently by means of a resistance of about 4000 ohms connected in series with the high-voltage plate lead. The rated plate voltage of this tube is high enough to be dangerous to the user. Great care should be taken during the adjustment of circuits, especially when the exposed circuit parts are at high d-c plate potential.

Operation

In Class B modulator or a-f service, the 810 input transformer should be designed to give good frequency response when operated into an open circuit, such as that represented by the grid circuit of the Class B stage when the signal amplitude is small. It should also be designed to handle the required input power for a strong signal. The output transformer should be designed so that the resistance load presented by the modulated Class C amplifier is reflected as the recommended plate-to-plate load in the Class B stage. Grid bias should be obtained from a battery or other d-c source of good regulation.

In Class B r-f service, the 810 may be supplied with bias from a battery, from a rectifier of good regulation, or from a cathode resistor, suitably by-passed for audio and radio frequencies.

In plate-modulated Class C r-f service, the 810 may be supplied with grid bias from a grid leak, or from a combination of grid leak and fixed supply, or grid leak and cathode resistor. The cathode resistor should be suitably by-passed for both audio and radio frequencies. The combination method of grid leak and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation.

In Class C r-f telegraph service, the 810 may be supplied with grid bias by any convenient method. When the 810 is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to maintain the plate current at a safe value. With plate voltage of 2250 volts, a fixed bias of at least -30 volts should be used.

If parasitic oscillations occur in the parallel or push-pull circuits, a noninductive resistance of 10 to 100 ohms connected in series with each grid lead as close to the grid terminal as possible, will often prevent oscillations.

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GENERAL ELECTRIC

Transmitting Tube GL-806 - - Installation and Operation

Installation

The base pins of the 806 fit the standard transmitting four-contact socket, such as the Type UT-541. The socket should be installed so that the tube will operate in a vertical position with the base down. If the tube is subjected to vibration or shock, a shock-absorbing suspension must be employed. Because of the relatively heavy filament current taken by this tube, the socket should make firm, large-surface contact with the filament-base pins. Heavy, well-soldered leads should be used for the filament-circuit wiring.

The bulb becomes very hot during continuous operation so that free circulation of air should be provided. Forced cooling is required for continuous key-down conditions in Class C telegraph service and is recommended for all classes of service at frequencies of 30 mc or higher. Forced cooling may be accomplished by means of an electric fan which directs air against the middle and upper sections of the bulb. Care should be taken that the bulb does not come in contact with any metallic object nor be subjected to the drops or spray of liquid. The installation of all wires and connections should be made so that they will not be close to or touch the bulb. This precaution is necessary in order to avoid puncture of the glass due to peak voltage effects.

The filament of the 806 is of the thoriated-tungsten type. It may be operated either from an a-c or a d-c source. Except where a d-c source is necessary to avoid hum, an a-c filament supply is generally used because of its convenience. The characteristics shown under Technical Information are based on the filament operated on alternating current. When direct current is used on the filament, the circuit returns should be connected to the negative filament terminal. A voltmeter should be connected permanently across the filament terminals to provide a ready check of the filament voltage. This voltage should not vary more than plus or minus 5 per cent from the rated value; otherwise, a loss of filament emission may result. The filament voltage may be removed for stand-by periods greater than fifteen minutes. There should be no reduction of filament voltage for periods of less than five minutes. Filament voltage may be reduced to eighty per cent during periods greater than five minutes if desired.

The plate dissipation of the 806 (the difference between plate input and power output) should never exceed the values given under Technical Information. The maximum plate-dissipation values are indicated by an orange-red color on the plate. It is normal for the plate to show some color, even at low loads.

Overheating of the 806 by severe overload may decrease filament emission. Unless the overload has liberated a large amount of gas, the activity of the filament can sometimes be restored by operating the filament at rated voltage for ten minutes or more with no voltage on the plate or grid. This process may be accelerated by raising the filament voltage to 6 volts (not higher) for a few minutes. In order to prevent overheating due to improper circuit adjustments, or to overloading, the positive plate supply lead should be provided with a protective device such as a fuse. This device should instantly remove the plate voltage when the d-c plate current reaches a value 50 per cent greater than normal.

Heavy leads and conductors together with suitable insulation should be used in all parts of the r-f plate tank circuit so that the losses, due to the r-f voltages and currents, may be kept at a minimum. Since proper circuit design becomes very important at the higher frequencies, it is essential that short, heavy leads and circuit returns be used in order to minimize lead inductance and losses.

In order that the maximum ratings given under Technical Information will not be exceeded, changes in plate and filament voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus, must be determined. An average value of plate and filament voltage should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced in order to prevent damage to the tube or associated apparatus in case the circuit adjustments are incorrect. It is advisable to use a protective resistance of about 10,000 ohms in series with the high-voltage plate lead during such adjustments. Suitable meters should be provided for measuring tube voltages and currents as well as for making transmitter adjustments. In modulated service, the use of a cathode-ray oscillograph also is recommended in the making of final adjustments for optimum performance. Under no conditions should the maximum values given under Technical Information be exceeded.

The rated plate voltage of this tube is high enough to be dangerous to the user. Great care should be taken during the adjustment of circuits, especially those in which the exposed circuit parts are at the high d-c plate potential.

Operation

As a Class B modulator or audio-frequency amplifier, two 806's are used in a balanced circuit, each tube amplifying only half the time. The d-c plate current should never exceed 200 milliamperes per tube. The input transformer should be designed to give good frequency response when operated into an open circuit, such as that represented by the grid circuit of the Class B stage when the signal amplitude is small. It should also be designed to handle the required input power for a strong signal. The output transformer should be designed so that the resistance load presented by the modulated Class C amplifier is reflected as a plate-to-plate load of 21,500 ohms in the Class B a-f stage for the 3000-volt condition. If an output transformer efficiency of 90 per cent is assumed, two 806's operated under conditions shown for a 3000-volt plate supply, are capable of modulating 100 per cent an input of approximately 1185 watts to a Class C r-f power amplifier. Since two 806's will modulate 1185 watts, a convenient Class C amplifier would be one operating at 2500 volts and 475 milliamperes. These conditions represent a resistance of approximately 5275 ohms. The ratio of the output transformer is then 21,500 ÷ 5275, or 2 to 1, step-down. The transformer should be designed with a core sufficiently large to avoid saturation effects which would impair the quality of the output. If the secondary is to carry the d-c plate current of the modulated amplifier, the core should be made larger and include an air gap to prevent saturation caused by the d-c plate current. Grid bias for Class B service should be obtained from a battery or other d-c source of good regulation. It should not be obtained from a high-resistance supply such as a grid leak, nor from a rectifier, unless the latter has exceptionally good voltage regulation.

As a Class B radio-frequency amplifier, the plate of the 806 is supplied with unmodulated d-c voltage and the grid is excited by r-f voltage modulated at audio frequency in one of the preceding stages. In this service the plate dissipation is greatest when the carrier is unmodulated. Under these conditions, the plate dissipation should not exceed 150 watts for unmodulated carrier conditions. Grid bias for Class B r-f service should be obtained in the same manner as for Class B a-f service.

As a plate-modulated Class C radio-frequency amplifier, the 806 should be used as shown under Technical Information. Grid bias for this service may be obtained from a grid leak of about 15,000 ohms (50-watt size), or from a suitable combination of either grid leak and fixed supply, or grid leak and cathode-bias resistor. The cathode-bias resistor should be suitably by-passed for audio and radio frequencies. The combination-bias methods are particularly desirable because distortion effects are minimized by bias-supply compensation. Grid-bias voltage for Class C service is not particularly critical so that correct adjustment may be obtained with values differing widely from those indicated for this service.

As a Class C radio-frequency amplifier and oscillator for telegraph service, the 806 may be used as shown under Technical Information. Grid bias for this service may be obtained from a grid leak of approximately 20,000 ohms, from a battery, from a rectifier, or from a cathode-bias resistor (preferably variable) suitably by-passed for radio frequencies. The cathode-bias method is advantageous due to the fact that the grid bias is automatically regulated in direct proportion to the sum of the plate and grid current and that there is little chance of the plate current becoming dangerously high, even if the r-f grid excitation is removed. The grid-leak-bias method has the advantage of simplicity and of automatically biasing the grid in proportion to the excitation voltage available. Special care must be

observed with the use of the latter system because the accidental removal of the excitation will cause the grid bias to fall to zero and the plate current to rise to an excessive value. The use of a protective device designed to open the plate circuit on excessive rises of plate current will minimize the danger of overload (see INSTALLATION). Since the grid-bias voltage for Class C service is not particularly critical, correct adjustment may be obtained with widely different values.

The maximum plate voltage values shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS for Class B services may be used provided the plate current for each service is limited so that the respective maximum plate input rating is not exceeded. In like manner, the maximum plate current values may be used provided the plate voltage for each service is limited so that the respective maximum plate input rating is not exceeded.

The d-c grid current will vary with individual tubes. Under no condition of operation should the maximum values under MAXIMUM RATINGS be exceeded.

The 806 may be operated at maximum ratings in all classes of service at frequencies as high as 30 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings remain the same as shown under TECHNICAL INFORMATION). The tabulation* shows the highest percentage of maximum plate voltage and power input that can be used at 30, 50, and 100 mc for any class of service. At these frequencies it is recommended that forced cooling be used to provide adequate ventilation (see INSTALLATION).

With the grid connected to the plate through the shortest possible connection, the resonant frequency of the grid-plate circuit is approximately 197 megacycles.

If more radio-frequency power output is required than can be obtained from a single 806, the push-pull or the parallel connection may be used. For example, two tubes connected in push-pull or in parallel will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage; the push-pull connection requires twice the r-f excitation voltage necessary to drive a single tube. With either connection, the driving power required is approximately twice that for single-tube operation while the grid bias is the same as that for a single tube. The push-pull arrangement has the advantage of balancing high-frequency circuits to ground and of cancelling the even-order harmonics from the output. When two or more 806's are operated in parallel, a noninductive resistance of 10 to 100 ohms should be placed in series with the grid lead of each tube, as close to the tube as possible, to prevent parasitic oscillations.

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Transmitting Tube GL-809 - - Installation and Operation

INSTALLATION

The base of the 809 fits the standard 4-contact socket such as the Type UR-542A. The socket should be installed to hold the tube in a vertical position with the base down. If it is necessary to place the tube in a horizontal position, the socket should be mounted with the filament-pin openings one vertically above the other so that the plate will be in a vertical plane (on edge). The plate lead of the tube is connected to a metal cap at the top of the bulb.

The bulb becomes very hot during continuous operation. Free circulation of air, therefore, should be provided. The installation of all wires and connections should be made so that they will not be close to or touch the bulb in order to avoid puncture of the glass.

The filament voltage should not vary more than plus or minus 5 per cent from the rated value; otherwise, a loss of filament emission may result. When the apparatus in which the tube is used is idle for short periods, the filament should be maintained at its rated voltage during the "stand-bys."

The plate of the 809 shows no color at the maximum plate-dissipation rating for each service.

Overheating of the 809 by severe overload may decrease its filament emission. The filament activity can sometimes be restored by operating the filament at rated voltage for ten minutes or more with no voltage on the plate or grid. This process may be accelerated by raising the filament voltage to 7.5 volts (not higher) for a few minutes. The positive high-voltage supply lead should be provided with a protective device, such as a high-voltage fuse. This device should instantly remove the plate voltage when the d-c plate current reaches a value of 50 per cent greater than normal.

In order that the maximum ratings given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS will not be exceeded, changes in plate and filament voltages due to line-voltage fluctuation, load variation, and manufacturirg variation of the associated apparatus, must be determined. An average value of plate and filament voltage should then be chosen so that under the usual voltage variations the maximum rated voltage will not be exceeded.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced in order to prevent damage to the tube or associated apparatus in case the circuit adjustments are incorrect. It is advisable to use a protective resistance of about 3000 ohms in series with the plate lead during such adjustments.

The rated plate voltage of this tube is high enough to be dangerous to the user. Care should be taken during the adjustment of circuits, especially when the exposed circuit parts are at high d-c plate potential.

OPERATION

In Class B modulator or audio-frequency service, two 809's are used in a balanced circuit, each tube amplifying half the time. The input transformer should be designed to give good frequency response when operated into an open circuit, such as that represented by the grid circuit of the Class B stage when the signal amplitude is small. It should also be designed to handle the required input power for a strong signal. The output transformer should be designed so that the resistance load presented by the modulated Class C amplifier is reflected as the recommended plate-to-plate load in the Class B a-f stage. Grid bias should be obtained from a battery or other d-c source of good regulation. It should not be obtained from a high-resistance supply such as a grid leak or a cathode-bias resistor. When the 809 is operated at a plate voltage of 500 volts or less, the tube may be operated with zero bias.

In Class B r-f service, the 809 may be used as shown under CHARACTERISTICS. The plate is supplied with unmodulated d-c voltage and the grid is excited by r-f voltage modulated at audio frequency in one of the preceding stages. The plate dissipation is greatest when the carrier is unmodulated. Grid bias for Class B r-f service may be obtained from a battery, from a rectifier of good regulation, or from a cathode resistor, suitably by-passed for audio and radio frequencies.

In plate-modulated Class C r-f service, the 809 may be supplied with grid bias from a grid leak, or from a suitable combination of either grid leak and fixed supply, or a grid leak and cathode resistor. The cathode resistor should be suitably by-passed for audio and radio frequencies. The combination-bias method of grid leak and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also minimizes distortion effects by bias-supply compensation. Grid-bias voltage for Class C service is not particularly critical so that correct adjustment may be obtained with values differing widely from those indicated for this service.

In Class C r-f telegraph service, the 809 may be supplied with grid bias by any convenient method.

The 809 may be operated at maximum ratings in all classes of service at frequencies as high as 60 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown under CHARACTERISTICS). The tabulation* shows the highest percentage of maximum plate voltage and power input that can be used up to 100 mc.

When more r-f power output is required than can be obtained from a single 809, the push-pull or the parallel connection may be used. For example, two tubes connected in push-pull or in parallel will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage; the push-pull connection requires twice the r-f excitation voltage necessary to drive a single tube. With either connection, the driving power required is approximately twice that for single-tube operation while the grid bias is the same as that for a single tube. The push-pull arrangement has the advantage of simplifying the balancing of high-frequency circuits and of cancelling the even-order harmonics from the output.

If parasitic oscillations occur in the parallel or the push-pull circuits, they can often be eliminated by connecting a noninductive resistor of 10 to 100 ohms in series with each grid lead, as close to the socket terminal as possible.

* See Description and Rating Sheet.

9-42 (3M)
Filing No. 8850

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

Transmitting Tube GL-803—Installation and Operation

Installation

The base of the 803 fits a special 5-contact transmitting socket, such as the Type UT-102A, which may be installed to hold the tube in a vertical position with the filament base either up or down. If it is necessary to place the tube in a horizontal position, the tube should be mounted with the plate in a vertical plane (on edge). If the tube is subjected to vibration or shock, a shock-absorbing suspension must be employed.

The bulb becomes very hot during continuous operation. Free circulation of air, therefore, should be provided. Care should be taken that the tube does not come in contact with any metallic object nor be subjected to the spray of liquid. The installation of all wires and connections should be made so that they will not be close to or touch the bulb in order to avoid puncture of the glass due to peak-voltage effects.

The filament voltage should not vary more than plus or minus 5 per cent from the rated value; otherwise, a loss of filament emission may result. The filament voltage may be removed for stand-by periods greater than fifteen minutes. There should be no reduction of filament voltage for periods of less than five minutes. The filament voltage may be reduced to eighty per cent during periods greater than five minutes if desired.

The screen voltage may be obtained from a separate source, from a voltage divider, or from the plate supply through a series resistor. The choice of method depends on the service in which the tube is used (see Operation). When the screen voltage is obtained from a separate source, or from a voltage divider, plate voltage should be applied before or with the screen voltage. Otherwise, with voltage on the screen only, the screen current may rise high enough to cause excessive screen dissipation. When the series-screen-resistor method is used, the resistor should have a value sufficient to drop the high voltage to a value within the maximum screen-voltage rating given under TECHNICAL INFORMATION. When the screen resistor method is used, it is important that the high-voltage switch be opened before the filament or the cathode circuit is opened and before the r-f grid excitation is removed. Unless this precaution is observed, the screen voltage will rise to an excessive value. A d-c milliammeter should be used in the screen circuit so that the screen current can be measured and the d-c power input to the screen determined. The screen should not be allowed to attain a temperature corresponding to more than a barely perceptible red color. This temperature corresponds to the screen input values shown under TECHNICAL INFORMATION.

The screen current is a very sensitive indication of plate-circuit loading and rises excessively, often to the point of damaging the tube, when the amplifier is operated without load. For this reason care should be taken when tuning the 803 under no-load conditions to prevent exceeding the screen-input rating of the tube.

Suppressor voltage may be obtained from any fixed-voltage d-c supply. In cases where the suppressor draws current, the supply should be a battery or other source having good regulation.

Overheating of the 803 by severe overload may decrease filament emission. Filament activity can sometimes be restored by operating the filament at rated voltage for ten minutes or more without voltage on the other electrodes. This process may be accelerated by raising the filament voltage to 12 volts (not higher) for a few minutes.

A protective device, such as a high-voltage fuse, should be used to protect both the screen and plate against overload. When a voltage divider of poor regulation or a series resistor is used for obtaining the screen voltage, the protective device should be placed in

the common positive high-voltage supply lead. It should remove the high-voltage supply when the d-c plate current reaches a value 50 per cent greater than normal. When a screen voltage is obtained from a separate source or from a voltage divider of good regulation, a protective device should also be placed in the screen-supply lead. It should remove the screen voltage when the d-c screen current reaches a value of 50 per cent greater than normal.

Shielding and isolation of the input and the output circuits are necessary for stable operation. If an external shield is used with the 803, it should be designed to enclose the base end of the tube and extend up to a position level with the internal circular disk located below the plate. Clearance between the glass bulb and external shield should be at least 1/16 in. The r-f impedance between the screen and filament must be kept low, usually by means of a suitable by-pass condenser. The capacitance of this condenser may be in the order of 0.001 to 0.01 uf. In telephony service when the screen is modulated, a smaller capacitance may be required in order to avoid excessive a-f by-passing. However, if the capacitance is too small, r-f feedback may occur between plate and control grid, depending on the circuit layout, operating frequency, and power gain of the stage.

In order that the maximum ratings given under TECHNICAL INFORMATION are not exceeded, changes in electrode voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus must be determined. An average value of voltage for each electrode should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate and screen voltage. This may be done conveniently by means of a protective resistance of about 5000 ohms in series with the high-voltage supply lead and, when a fixed screen-voltage supply is used, a protective resistance of about 5000 ohms in series with the screen lead.

Operation

In Class B r-f pentode service, the 803 is supplied with unmodulated d-c plate voltage. The grid is excited by r-f voltage modulated at audio frequency in one of the preceding stages. Under these conditions, the plate dissipation is greatest when the carrier is unmodulated. The screen voltage should be obtained from a separate source or from a potentiometer connected across the plate supply. The suppressor voltage may be obtained from any fixed d-c supply. In cases where the suppressor draws current, the supply should be a battery or other d-c source of good regulation. Control-grid bias may be obtained from a battery, from a rectifier of good voltage regulation, or from a cathode resistor, suitably by-passed for audio and radio frequencies.

In suppressor-modulated Class C r-f service, the 803 is supplied with unmodulated d-c plate voltage. The control grid is supplied with unmodulated r-f voltage and the suppressor with negative d-c voltage modulated at audio frequency. The screen voltage should be obtained through a resistor in series with the plate supply (see INSTALLATION). The d-c suppressor voltage may be obtained from any fixed supply. Control-grid bias may be obtained from a grid leak, from a cathode resistor, or from a fixed supply. The cathode resistor should be by-passed for audio and radio frequencies. The grid-leak-bias method has the advantage of simplicity and of automatically biasing the grid in proportion to the excitation voltage available.

In grid-modulated Class C r-f pentode service, the 803 is supplied with unmodulated d-c plate voltage. The control-grid bias is modulated at audio frequency. The suppressor voltage may be obtained from a battery or from a fixed supply of good regulation. The audio power required in this service is very small, being sufficient only to meet the peak grid-power requirement of the Class C amplifier on the positive crest of the input signal. The actual value is generally never more than 2 watts, depending on circuit adjustments.

In plate-modulated Class C r-f pentode service, the screen voltage may be obtained from a fixed supply, or through

a voltage-dropping resistor in series with the modulated plate supply. The screen voltage must be modulated with the plate voltage so that the ratio of screen voltage to plate voltage remains constant. Modulation of a fixed screen-voltage supply can be accomplished either by connecting the screen to a separate winding on the modulation transformer or by connecting it through a blocking condenser to a tap on the modulation transformer or choke. With the latter method, an a-f choke of suitable impedance for low audio frequencies should be connected in series with the screen-supply lead. The suppressor voltage may be obtained from any fixed supply. Control-grid bias may be obtained from a grid leak, or from a combination of either grid leak and fixed supply or grid leak and cathode resistor. The combination method of grid leak and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation.

In plate-modulated Class C r-f tetrode service, grids No. 2 and No. 3 are connected together as the screen. The screen voltage may be obtained through a voltage-dropping resistor connected in series with the unmodulated plate-voltage supply. In this case, the series resistor develops its own modulating voltage. The screen voltage may also be obtained from a separate source, or from a voltage divider across the plate-voltage supply, provided the screen voltage is modulated as discussed under plate-modulated Class C r-f amplifier service (pentode connection) for a fixed screen supply. Control-grid bias considerations are the same as those for plate-modulated Class C pentode service.

In Class C telegraph service with the pentode connection, the 803 should be supplied with screen voltage from a fixed supply, such as a voltage divider or a separate source. The regulation of the supply need only be good enough to prevent the screen voltage from rising higher than twice the maximum screen-voltage rating under key-up conditions. The screen voltage should not be obtained from a series screen resistor. The suppressor voltage may be obtained by any of the methods shown under INSTALLATION. Control-grid bias may be obtained by any convenient method.

In Class C telegraph service with the tetrode connection, grids No. 2 and No. 3 are connected together to comprise the screen. Screen voltage and control grid-bias considerations are the same as for pentode Class C telegraph service.

The 803 may be operated at maximum ratings in all classes of service at frequencies as high as 20 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown under TECHNICAL INFORMATION. The tabulation* shows the highest percentage of maximum plate voltage and power input that can be used up to 70 mc for any class of service. Special attention should be given to shielding and to r-f by-passing at these frequencies. When shielding is used, care should be taken to insure adequate tube ventilation and the maintenance of normal ambient temperature.

* See Description and Rating Sheet.

GENERAL ELECTRIC

SCHENECTADY, N.Y.

4-44 (10M)
Filing No. 8850

Supersedes GEH 1115A

GENERAL ELECTRIC

Transmitting Tube GL-802 - - Installation and Operation

INSTALLATION

The base of the GL-802 fits a 7-contact (0.855-inch pin-circle diameter) socket which may be installed to hold the tube in any position. The plate lead of the tube is brought out at the top of the bulb to a metal cap.

The heater is designed to operate at 6.3 volts under normal conditions of line-voltage variation.

The cathode circuit of the 802 should be connected to the electrical midpoint of the heater circuit when the heater is operated from an a-c supply. When the heater is operated from a d-c source, the cathode circuit is tied to the negative heater-supply lead. In circuits where the cathode is not directly connected to the heater, the potential difference between them should not exceed 100 volts. If the use of a large resistor is necessary between heater and cathode in some circuit designs, it should be by-passed by a suitable filter network to avoid the possibility of hum.

The plate of the 802 shows no color at the maximum plate-dissipation rating for each class of service.

The screen voltage may be obtained from a separate source, from a potentiometer, or from the plate supply through a series resistor. The choice of method depends on the service in which the tube is used (see APPLICATION). When the screen voltage is obtained from a separate source, or from a potentiometer, plate voltage should be applied before or with the screen voltage. Otherwise, with voltage on the screen only, the screen current may rise high enough to cause excessive screen dissipation. When screen-voltage regulation is not an important factor, the series-resistance method for obtaining screen voltage is desirable because of its simplicity and because it limits the d-c power input to the screen. A d-c milliammeter should be used in the screen circuit so that the screen current can be measured and the d-c power input to the screen determined. The screen should not be allowed to attain a temperature corresponding to more than a barely perceptible red color. This temperature corresponds to the screen input value shown under CHARACTERISTICS.

Suppressor voltage for the 802 may be obtained from any suitable d-c supply. In cases where the suppressor draws current, the supply should be a battery or other d-c source of good regulation.

The internal shield is brought out of the tube to its own separate base pin. The internal shield should be connected to a terminal operating at zero r-f and/or a-f potential. In most cases, this connection will be made to the cathode or suppressor terminal.

A protective device, such as a high-voltage fuse, should be used to protect both the screen and plate against overload. When a bleeder resistor of poor regulation or a series resistor is used for obtaining the screen voltage, the protective device should be placed in the common positive high-voltage supply lead. It should remove the high-voltage supply when the d-c plate current reaches a value 50 per cent greater than normal. When a screen voltage is obtained from a separate source or from a bleeder of good regulation, a protective device should also be placed in the screen-supply lead. It should remove the screen voltage when the d-c screen current reaches a value of 50 per cent greater than normal.

Shielding and isolation of the input and the output circuits are necessary for stable operation. If an external shield is used with the 802, it should be designed to enclose the base end of the tube and extend up to a position level with the bottom of the internal shield. Clearance between the glass bulb and external shield should be at least 1/16 inch. The r-f impedance between the screen and filament must be kept low, usually by means of a suitable by-pass condenser. The capacitance of this condenser may be in the order of 0.01 to 0.1 μf in telephony service when the

screen is modulated; a smaller capacitance may be required in order to avoid excessive a-f by-passing. However, if the capacitance is too small, r-f feedback may occur between plate and control grid, depending on the circuit layout, operating frequency, and power gain of the stage. A-f by-passing difficulties can usually be eliminated if the screen by-pass condenser is replaced by a series-tuned circuit to resonate at the operating frequency. The series-tuned circuit presents a high impedance to audio frequencies but a very low impedance to its resonant frequency.

In order that the maximum ratings given under CHARACTERISTICS are not exceeded, changes in electrode voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus must be determined. An average value of voltage for each electrode should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate and screen voltage. This may be done conveniently by means of a protective resistance of about 4000 ohms in series with the high-voltage supply lead and, when a fixed screen-voltage supply is used, a protective resistance of about 3000 ohms in series with the screen lead.

The rated plate voltage of this tube is high enough to be dangerous to the user. Care should be taken during the adjustment of circuits, especially when exposed circuit parts are at high d-c plate potential.

OPERATION

In Class A power amplifier pentode, the 802 may be operated as shown under CHARACTERISTICS. In this service the screen voltage should be obtained from a separate source or from a potentiometer connected across the power supply. The suppressor should be connected to the cathode at the socket. Control-grid bias may be obtained from a fixed supply or from a cathode-bias resistor. The d-c resistance in the grid circuit should not exceed 10,000 ohms with fixed bias, or 500,000 ohms with cathode bias.

In Class B r-f pentode service, the 802 is supplied with unmodulated d-c plate voltage. The grid is excited by r-f voltage modulated at audio frequency in one of the preceding stages. Under these conditions, the plate dissipation is greatest when the carrier is unmodulated. The screen voltage should be obtained from a separate source or from a potentiometer connected across the plate supply. The suppressor voltage may be obtained from any fixed d-c supply. In cases where the suppressor draws current, the supply should be a battery or other d-c source of good regulation. Control-grid bias may be obtained from a battery, from a rectifier of good voltage regulation, or from a cathode resistor, suitably by-passed for audio and radio frequencies.

In suppressor-modulated Class C r-f service, the 802 is supplied with unmodulated d-c plate voltage. The control grid is supplied with unmodulated r-f voltage and the suppressor with negative d-c voltage modulated at audio frequency. The screen voltage should be obtained through a resistor in series with the plate supply (see INSTALLATION). The d-c suppressor voltage may be obtained from any fixed supply. Control-grid bias may be obtained from a grid leak, from a cathode resistor, or from a fixed supply. The cathode resistor should be by-passed for audio and radio frequencies. The grid-leak-bias method has the advantage of simplicity and of automatically biasing the grid in proportion to the excitation voltage available. Special care must be observed with the use of this system because the accidental removal of the excitation will cause the grid bias to fall to zero and the plate current to rise to an excessive value. The use of a protective device designed to remove the screen and plate voltages on excessive rises of plate current will minimize the danger of overload (see INSTALLATION). Control-grid bias is not critical so that correct adjustment may be obtained with widely different values.

In grid-modulated Class C r-f pentode service, the 802 is supplied with unmodulated d-c plate voltage. The control-grid bias is modulated at audio frequency. The screen voltage should be obtained from a separate source or from

a potentiometer connected across the plate supply. The suppressor voltage may be obtained from a battery or from a fixed supply of good regulation. Control-grid bias should be obtained from a battery or other d-c source of good regulation. It should not be obtained from a high-resistance supply. The audio power required in this service is very small, being sufficient only to meet the peak grid-power requirement of the Class C amplifier on the positive crest of the input signal. The actual value is generally never more than 0.5 watt, depending on circuit adjustments.

In plate-modulated Class C r-f pentode service, the 802 can be modulated 100 per cent. The screen voltage may be obtained from a fixed supply, or through a voltage-dropping resistor in series with the modulated plate supply. The screen voltage must be modulated with the plate voltage so that the ratio of screen voltage to plate voltage remains constant. Modulation of a fixed screen-voltage supply can be accomplished either by connecting the screen to a separate winding on the modulation transformer or by connecting it through a blocking condenser to a tap on the modulation transformer or choke. With the latter method, an a-f choke of suitable impedance for low audio frequencies should be connected in series with the screen-supply lead. The suppressor voltage may be obtained from any fixed supply. Control-grid bias may be obtained from a grid leak, or from a combination of either grid leak and fixed supply or grid leak and cathode resistor. The combination method of grid leak and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation. Grid-bias voltage for this service is not particularly critical so that correct adjustment may be obtained with values differing widely from those indicated for this service.

In plate-modulated Class C r-f tetrode service, the 802 is capable of being modulated 100 per cent. Grids No. 2 and No. 3 are connected together as the screen. The screen voltage may be obtained through a voltage-dropping resistor connected in series with the unmodulated plate-voltage supply. In this case, the series resistor develops its own modulating voltage. The screen voltage may also be obtained from a separate source, or from a potentiometer across the plate-voltage supply, provided the screen voltage is modulated as discussed under plate-modulated Class C r-f amplifier service (pentode connection) for a fixed screen supply. Control-grid bias considerations are the same as those for plate-modulated Class C pentode service.

In Class C telegraph service with the pentode connection, the 802 may be operated with screen and suppressor voltage obtained in the manner discussed under INSTALLATION. Grid bias may be obtained by any convenient method.

In Class C telegraph service with the tetrode connection, grids No. 2 and No. 3 are connected together to comprise the screen. The screen voltage may be obtained by any of the methods discussed under INSTALLATION. Grid bias may be obtained by any convenient method.

As a pentode or tetrode oscillator (crystal or self excited), the 802 may be operated under the conditions shown for Class C telegraph services. Because the internal shielding in this tube is unusually effective, it generally is necessary to introduce external feedback in those circuits which depend on the control-grid-to-plate capacity for oscillation. This may be done by the use of a small condenser not larger than 2 to 3 $\mu\mu f$ connected between control grid and plate.

The 802 may be operated at maximum ratings in all classes of service at frequencies as high as 30 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under CHARACTERISTICS.) The tabulation* shows the highest percentage of maximum plate voltage and power input that can be used up to 110 mc for any class of service. Special attention should be given to shielding and to r-f by-passing at these frequencies. When shielding is used, care should be taken to insure adequate tube ventilation and the maintenance of normal ambient temperature.

* See Description and Rating Sheet

If more r-f power output is required than can be obtained from one 802, the push-pull or the parallel circuit may be used. For example, two tubes connected in push-pull or in parallel will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage; the push-pull connection requires twice the r-f excitation voltage necessary to drive one tube. With either connection the driving power required is approximately twice that for single-tube operation while the grid bias is the same as for a single tube. The push-pull arrangement has the advantage of balancing high-frequency circuits to ground and of cancelling the even-order harmonics from the output. If parasitic oscillations occur in the parallel or the push-pull circuits, a non-inductive resistor of 10 to 100 ohms connected in series with the grid leak of each tube, as close to the socket as possible, will often prevent the oscillations.

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GENERAL ELECTRIC

Transmitting Tube GL-1619 - - Installation and Operation

INSTALLATION

The base pins of the 1619 fit the standard octal socket which should be installed to hold the tube in a vertical position with the base either up or down. If the tube is subjected to vibration or shock, a shock-absorbing suspension should be employed.

The filament is designed to provide a minimum of delay in starting the tube. The filament is of the coated type and may be operated either from an a-c or d-c source. The characteristics shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS are based on a-c filament operation.

The beam-forming plates of the 1619 are connected to a separate base pin. They should always be operated at zero potential with respect to the filament; never positive. When the filament is operated from an a-c supply, the beam-forming plates should be connected to the mid-point of the filament circuit. When the filament is operated from a d-c supply, they should be connected to the negative end of the filament.

The screen voltage may be obtained from a separate source, from a potentiometer, or from the plate supply through a series resistor. The choice of method depends on the service in which the tube is used (see OPERATION). When the screen voltage is obtained from a separate source, or from a potentiometer, plate voltage should be applied before or with the screen voltage. Otherwise, with voltage on the screen only, the screen current may rise high enough to cause excessive screen dissipation. When screen-voltage regulation is not an important factor, the series resistance method for obtaining screen voltage is desirable because of its simplicity and because it limits the d-c power input to the screen. A d-c milliammeter should be used in the screen circuit so that the screen current can be measured and the d-c power input to the screen determined.

In all services, precautions should be taken to insure that the plate and screen dissipation ratings are not exceeded with expected supply-voltage variation, especially when fixed bias is used. In order that the maximum ratings given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS will not be exceeded, changes in plate and filament voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus, must be determined. An average value of plate and filament voltage should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

A protective device, such as a high-voltage fuse, should be used to protect both the screen and plate against overloads. When a bleeder resistor of poor regulation or a series resistor is used for obtaining the screen voltage, this device should be placed in the common positive high-voltage supply lead. It should remove the high-voltage supply when the d-c plate current reaches a value 50 per cent greater than normal. When the screen voltage is obtained from a separate source or from a bleeder of good regulation, a protective device should also be placed in the screen-supply lead. It should remove the screen voltage when the d-c screen current reaches a value of 50 per cent greater than normal.

Shielding and isolation of the input and output circuits are required for stable operation. The impedance between the screen and cathode must be kept low, usually by means of a suitable by-pass condenser. When the screen voltage is obtained from the plate supply through a series resistor, the screen by-pass condenser should have a voltage rating at least equal to the d-c plate voltage applied to the tube. The capacitance value of this condenser may be in the order of 0.01 to 0.1 uf. In telephony service when the screen is modulated, a

smaller capacitance may be required in order to avoid excessive a-f by-passing. However, if the capacitance is too small, r-f feedback may occur between plate and control grid, depending on the circuit layout, operating frequency, and power gain of the stage. A-f by-passing difficulties can usually be eliminated if the screen by-pass condenser is replaced by a series-tuned circuit to resonate at the operating frequency. The series-tuned circuit presents a high impedance to audio frequencies but a very low impedance to its resonant frequency.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate and screen voltage. This may be done conveniently by means of a protective resistance of about 10000 ohms, total, in series with the screen lead and a protective resistance of about 3000 ohms in series with the high-voltage supply lead.

OPERATION

In class A_1 power amplifier service, the 1619 may be operated as shown under CHARACTERISTICS. The values are for fixed-bias operation and have been determined on the basis that no grid current flows during any part of the input signal swing. The second harmonics can easily be eliminated by the use of push-pull circuits. In single-tube, resistance-coupled circuits, the second-harmonics can be minimized by generating out-of-phase second harmonics in the pre-amplifier.

In push-pull class AB_2 power amplifier service, the 1619 may be operated as shown under CHARACTERISTICS. The values are for fixed-bias operation and have been determined on the basis that no grid current flows during any part of the input signal swing.

In push-pull Class AB_2 amplifier service, the 1619 may be operated as shown under CHARACTERISTICS. The values cover operation with fixed bias and have been determined on the basis that some grid current flows during the most positive swing of the input signal.

The type of input coupling used in audio-frequency services should not introduce too much resistance in the grid-circuit. The maximum values are shown under CHARACTERISTICS. Transformer- or impedance-coupling devices are recommended.

In grid-modulated class C telephone service, the 1619, is supplied with unmodulated r-f grid excitation voltage and with a d-c grid bias which is modulated at audio frequencies. Grid bias should preferably be obtained from an unby-passed cathode resistor, although it may also be obtained from a fixed supply or a grid leak. The plate is supplied with unmodulated d-c voltage. The audio power required in this service is very small, being sufficient only to meet the peak grid power requirement of the class C amplifier on the positive crest of the input signal. The screen voltage should be obtained from a separate source or from a potentiometer connected across the plate supply.

In plate-modulated class C r-f amplifier service, the GL-1619 can be modulated 100 per cent. The screen voltage may be obtained from a fixed supply or from a voltage-dropping resistor in series with the modulated plate supply. The screen voltage must be modulated simultaneously with the plate voltage so that the ratio of screen voltage to plate voltage remains constant. Modulation of a fixed screen-voltage supply can be accomplished either by connecting the screen lead to a separate winding on the modulation transformer or by connecting it through a blocking condenser to a tap on the modulation transformer or choke. When the latter method is used, an a-f choke of suitable impedance for low audio frequencies should be connected in series with the screen-supply lead. Control-grid bias may be obtained from a grid leak or from a combination of either grid leak and fixed supply, or grid leak and cathode-bias resistor. The combination method is particularly desirable because distortion effects are minimized by bias-supply compensa-

tion. Grid-bias voltage for class C service is not particularly critical so that correct adjustment may be obtained with values differing widely from those indicated for this service.

In class C r-f telegraph service, the 1619 may be supplied with screen voltage by any of the methods shown under INSTALLATION. Grid bias may be obtained from a grid leak, from a battery, from a rectifier, or from a cathode-bias resistor (preferably variable) suitably by-passed for radio frequencies. Since grid-bias voltage for class C service is not critical, correct adjustment may be obtained with widely different values.

The GL-1619 may be operated at maximum ratings in all classes of service at frequencies as high as 45 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS,) so that at 90 megacycles the plate voltage and power input are only 75 per cent of the maximum ratings. Special attention should be given to shielding and to r-f bypassing at the higher frequencies.

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Transmitting Tube GL-892-R - - Installation and Operation

Installation

The handling of the 892-R in transportation and storage requires great care, since the tube may be permanently damaged if subjected to sudden jars. Each 892-R is suspended within its shipping crate so that it will not come in contact with the sides of the crate during shipment. The tube should be stored in the crate with the filament end up and should be protected from moisture and extreme temperature changes. Furthermore, while the tube is being handled, it should be kept in a vertical position with the filament end up. Under no circumstances should crated tubes be piled on top of one another. The weight of the tube with the air-cooled radiator is 40 pounds uncrated and approximately 90 pounds crated.

It is recommended that the tube be tested upon receipt in the equipment in which it is to be used. Before the tube is placed in operation, care should be taken that the glass bulb, and particularly the entrant glass area around the filament leads, is free from foreign matter. These leads become so hot during operation that any paper, shavings, or excelsior, not removed from the stem may become charred and cause puncture of the bulb. An air blast is recommended for removing such material.

The mounting of the 892-R requires the use of the permanently fitted air-cooled radiator. Supplementary equipment includes a grid-terminal connector and several filament-terminal connectors. The connectors usually are part of the transmitter equipment. The tube should be supported in a vertical position with the glass end up. If the 892-R is subjected to appreciable vibration in service, it is advisable to support the mounting frame, or the mounting itself, by springs. The installation of all wires and connectors must be made so that they will not be close to or touch the bulb. This precaution is necessary in order to avoid almost certain puncture of the glass from corona discharge. Connections to the grid and filament connectors must have some degree of flexibility in order not to put a stress on the grid cap or filament-terminal posts. The leads should be fastened to the terminal clamps before they are placed in position. When the leads are soldered to the clamps, a hard type solder should be used. This solder should remain firm at temperatures of 250 C, or more. When the Clamps are in place, carefully tighten the setscrews to insure good electrical contact. Connections should never be soldered directly to the tube terminals as the heat of the soldering operation may result in the cracking of the seal. The grid terminal cap should not be used to support coils, condensers, chokes, or other circuit parts.

The cooling of the 892-R is accomplished by means of an air-cooled fin radiator which is permanently fitted to the plate at the factory. This radiator must be cooled by means of a vertical air blast of 400 to 600 cubic feet per minute. The temperature of the cooling air should not exceed 45 C. The air-cooling system should be properly installed to insure safe operation of the tube under all conditions and for this reason should be electrically interconnected with the filament and plate supply to prevent the application of voltages to the tube without suitable cooling. Air-pressure interlocks which open the circuit breakers of the filament- and plate-power transformers, are necessary for protecting the tube when the air flow is insufficient or ceases. The radiator is equipped with two wells, one of which is for the insertion of a thermometer to indicate the radiator temperature.

The tungsten filament of the 892-R is of the double-unit type. One end of each unit is brought out of the tube to a common terminal. The other two ends are brought out to separate terminals.

The common terminal of the base is larger in diameter than the two end terminals. By proper filament connection, this arrangement makes possible the operation of the filament from two-phase and single-phase alternating current, as well as from direct current. See page 6. For normal operation, each filament unit requires a filament voltage of 11 volts at a current of 60 amperes. The grid and plate returns should be connected to one side of the filament supply when direct current is used, to the center tap of the filament transformer when a single-phase a-c supply is used, and through a balancing resistor to the mid-point of each secondary coil of a two-phase transformer when a two-phase a-c supply is used. When direct current is used, the polarity of the filament leads should be reversed every 500 hours of operation. The filament should be operated at constant voltage rather than constant current and must be allowed to reach at least 80 per cent normal voltage before plate voltage is applied. Intermittent power supply interruptions may be allowed provided the time off does not exceed one second. If the tube is to be used at relatively low output, the plate current will be less than normal, requiring less than normal emission of the filament. The filament, therefore, may be operated at a voltage slightly lower than rated voltage, giving longer life. The permissible reduction in filament voltage may be checked by reducing the filament voltage with the transmitter under normal operation to a value where reduction in output or increase in distortion can just be detected. The filament voltage must then be increased by an amount equivalent to the maximum percentage regulation of the filament supply voltage. Care must be taken that sufficient emission is provided. Otherwise, instability of operation or excessive distortion may be experienced, or the rated plate dissipation of the tube may be exceeded. From the viewpoint of tube life it is usually economically advantageous to provide good regulation of the filament voltage. For example, if the filament is operated continuously at 6 per cent above normal voltage, the evaporation life will be reduced to approximately one half. The filament voltmeter should be connected to indicate voltage at the filament terminals. Since the filament current of the 892-R is very high, the filament connectors should be large and make good contact. The filament base of the 892-R should not be connected to ground or to any part of the circuit.

A <u>filament starter</u> should be used to raise the filament voltage gradually and to limit the high initial rush of current through the filament when the circuit is first closed. The starter may be either a system of time-delay relays cutting resistance out of the circuit, a high-reactance filament transformer, or a simple rheostat. Regardless of the method of control, it is important that the filament current per unit never exceed, even momentarily, a value of 120 amperes. Whenever the filament voltage is turned off, it is advisable to reduce the voltage gradually in steps over a period of 2 to 3 minutes. This precaution is necessary to avoid undue mechanical tension and premature filament breakage caused by the difference in cooling rate of the heavy filament center post and the thin filament strands.

The plate circuit should be provided with a time-delay relay which will prevent the application of plate voltage until the filament has reached normal operating temperature.

When the apparatus in which the tube is used is to be idle for periods not exceeding 2 hours, voltage should be maintained on the filament. However, if desired, provision may be made to reduce the filament voltage to approximately 80 per cent of the rated value during "stand-bys." Where stand-by periods exceed two hours the filament voltage may be removed.

<u>The maximum radiator temperature must not be exceeded under any condition</u>. Air-pressure interlocks which prevent the application of plate and filament voltages under conditions of inadequate air supply should be provided.

Overheating of the 892-R by severe overload may impair its vacuum. Unless the overload has liberated a large amount of gas, it is often possible to degasify the tube by operating it as an r-f power amplifier or oscillator at reduced plate voltage. The first step in the process should be a short period of operation at a plate voltage of 5000

volts or less. The voltage may then be raised in steps of about 2000 volts until the normal operating voltage is attained. At each new voltage, the tube should be operated long enough to insure the attainment of stable conditions.

In order to prevent excessive plate-current flow and the resultant overheating, the ground lead of the plate circuit should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to open the circuit breakers in the primary of the rectifier transformer at slightly higher than normal plate current. The total time required for the operation of the relay and circuit breakers should be about one-tenth second and not more than one-sixth second. A voltage-dropping resistor should be connected permanently in series with the plate lead of each tube for protection of the tube during the time required for the protective relay and circuit breaker to act. The minimum value of this resistor which will give adequate protection with minimum power loss is as follows:

Series Resistor	25	50	200	250	275	300	Ohms
Maximum Power Output of Rectifier	16	40	100	250	640	1600	Kw

Precautions must be taken so that no high capacitance is connected directly across the tube in any manner such that a disturbance within the tube will discharge appreciable energy from the capacitor.

Suitable meters should be provided for the reading of filament voltage, d-c plate voltage, d-c grid voltage, d-c plate current, d-c grid current, and r-f grid current, as well as for the recording of tube life (hours of operation). In addition to the use of meters for indicating suitable operating conditions, their use is also of value in making transmitter adjustments. In modulated service, a cathode-ray oscillograph is recommended to assist in the making of final adjustments for optimum performance. Under no conditions should the maximum values given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS be exceeded.

Heavy leads and conductors together with suitable insulation should be used in all parts of the r-f plate tank circuit so that the losses due to the r-f voltages and currents may be kept at a minimum. Because proper circuit design becomes very important at the higher frequencies, short, heavy leads and circuit returns are essential in order to minimize lead inductance and losses.

When an 892-R is first placed in operation, care should be taken to see that the air-cooling system is functioning properly. The tube should then be operated without plate voltage for five minutes at rated filament voltage. After this initial preheating schedule, the plate voltage can be applied. Start with not more than one-half the usual operating voltage and then carefully increase it in steps of about 2000 volts over a period of approximately 15 minutes to the desired value. The tube should then be operated under the normal load conditions for a period of one hour or more. The plate voltage is usually varied by means of primary taps on the plate transformer. The plate-circuit relay should be open when the transformer primary taps are changed in order to avoid dangerous voltage surges. It is recommended that every three months spare tubes be given the preheating and initial operation schedule as discussed above. This will insure that only good tubes are carried in stock.

In order that the maximum ratings given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS will not be exceeded, changes in plate and filament voltages due to line-voltage fluctuation load variation, and manufacturing variation of the associated apparatus, must be determined. An average value of plate- and filament-supply voltage should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced to one-half the rated value to prevent damage to the tube or associated apparatus. After correct adjustment has been made with the tube operating smoothly and without excessive heating, the plate voltage may be raised in several steps to the desired value. Adjustments should be made at each step for optimum operation.

Protective devices are essential for the 892-R, as in the case of other power equipment of high capacity, and are summarized as follows. Air-pressure interlocks which open the circuit breakers in the primary circuits of the filament and plate power transformers are necessary for protecting the tube when the cooling system fails. A time-delay relay should be used in the plate circuit to prevent application of plate voltage until the filament has reached at least 80 per cent normal voltage. The ground lead of the plate circuit should be provided with an instantaneous overload relay to prevent excessive plate current and tube overheating. In addition to the latter precaution, a voltage-dropping resistor should be connected permanently in series with the plate lead to protect the tube during the time required for the protective relay and circuit breaker to act.

The rated plate voltage of the 892-R is extremely dangerous to the user. Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which are at a high potential above ground, should be enclosed in a protective housing. This housing may be of fibre or similar insulating material. If metal housing is used, care should be taken that it does not absorb excessive power. The protective housing should be designed with automatic interlocks so that the operating personnel cannot possibly come in accidental contact with any high-voltage point in the electrical system. These interlock devices should function to break the primary circuit of the plate-voltage supply when any gate or door on the protective housing is opened, and should prevent the closing of this primary circuit until the door is again locked.

Operation

As a Class B modulator or audio-frequency amplifier, two 892-R's are used in a balanced circuit, each tube amplifying only half the time. The input transformer should be designed to give good frequency response when operated into an open circuit, such as that represented by the grid circuit of the Class C stage when the signal amplitude is small. It should also be designed to handle the required input power for a strong signal. The output transformer should be designed so that the resistance load presented by the modulated Class C amplifier is reflected as a plate-to-plate load of 8400 ohms in the Class B stage for the 10,000-volt conditions. It should have a core sufficiently large to avoid saturation effects which would impair the quality of the output. Grid bias for the 892-R in Class B a-f service should be obtained from a generator or other d-c source of excellent regulation. It should not be obtained from a high-resistance supply such as a grid leak, nor from a rectifier, unless the latter has exceptionally good voltage regulation. Each gird circuit should be provided with a separate grid-bias adjustment in order to balance the grid and plate current.

As a Class B radio-frequency amplifier, the 892-R may be used as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS. In Class B r-f service, the plate is supplied with unmodulated d-c voltage. The grid is excited by r-f voltage modulated at audio-frequency in one of the preceding stages and the power output is proportional to the square of the grid-excitation voltage. Under these conditions, the plate dissipation is greatest when the carrier is unmodulated. Grid bias should be obtained from a generator, from a rectifier of excellent regulation, or from a cathode-bias resistor, suitably bypassed for audio and radio frequencies.

As a plate-modulated Class C radio-frequency amplifier, the 892-R may be used as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS. Grid bias for this service may be obtained from a grid leak of approximately 5500 ohms, or from a suitable combination of either grid leak and fixed supply, or grid leak and cathode-bias resistor. The cathode-bias resistor should be suitably bypassed for audio and radio frequencies. The combination-bias methods are particularly desirable because distortion effects are minimized by bias-supply compensation. Grid-bias voltage for Class C service is not particularly critical so that correct adjustment may be obtained with values differing widely from those indicated for this service

As a Class C radio-frequency amplifier and oscillator for telegraph serv-

ice, the 892-R may be used as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS. Grid bias for this service may be obtained from a grid leak of 5500 to 7500 ohms, from a generator, from a rectifier, or from a cathode-bias resistor (preferably variable) suitably by-passed for radio frequencies. The cathode-bias method is advantageous due to the fact that the grid bias is automatically regulated in direct proportion to the sum of the plate and the grid current and that there is little chance of the plate current becoming dangerously high, even if the r-f grid excitation is removed. Grid-leak bias has the advantage of simplicity and of automatically biasing the grid in proportion to the excitation voltage available. The use of protective devices (see INSTALLATION) designed to open the plate circuit on excessive rises of plate current minimizes danger of overload. Since grid-bias voltage for Class C service is not particularly critical, correct circuit adjustment may be obtained with values differing widely from those indicated for this service.

The grid circuit must be so arranged that it is impossible for high voltages to be established between the grid and filament at any frequency except the fundamental in order to prevent parasitic oscillations. The grid voltage at the fundamental frequency should be sufficient to provide only the necessary grid excitation for the tube. Because of the high current carried by the grid lead and its adjoining circuit, heavy conductors carefully connected should be used.

The d-c grid current and the r-f grid current should never exceed the values given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS. Operating values will vary with individual tubes and circuits.

The 892-R may be operated at maximum ratings in all classes of service at frequencies up to 1.5 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.) The tabulation* shows the highest percentage of maximum plate voltage and power input that can be used at 1.5, 7.5, and 20 mc for any class of service. Special attention should be given to adequate cooling and the maintenance of normal ambient temperatures at these frequencies.

With the grid connected to the plate through the shortest possible connection, the resonant frequency of the grid-plate circuit is approximately 60 megacycles.

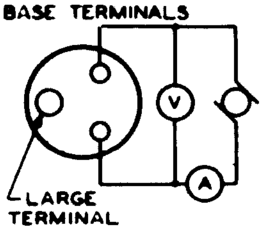
If more radio-frequency power output is required than can be obtained from a single 892-R, the push-pull or the parallel connection may be used. For example, two tubes connected in push-pull or in parallel will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage; the push-pull connection requires twice the r-f excitation voltage necessary to drive a single tube. With either connection the driving power required is approximately twice that for single-tube operation while the grid bias is the same as for a single tube. The push-pull arrangement has the advantage of balancing the circuit with respect to ground and of cancelling the even-order harmonics from the output. When the parallel connection is used, a noninductive resistor of 10 to 100 ohms and a choke coil or other suitable network should be placed in series with the grid lead of each tube, as close to the tube as possible, in order to prevent parasitic oscillations. With either connection, it is preferable to provide for a separate grid-bias or grid-excitation adjustment in order to balance the grid and the plate current.

Careful handling and conservative operation of the 892-R will result in longer life and more satisfactory performance.

* See Description and Rating Sheet

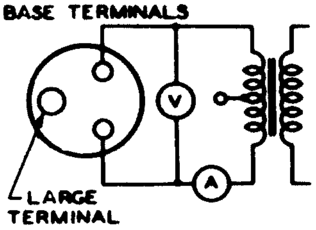
FILAMENT CONNECTIONS

WITH D-C EXCITATION



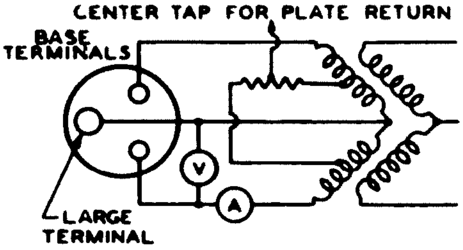
V = 22 VOLTS
A = 60 AMPERES

WITH SINGLE-PHASE A-C EXCITATION



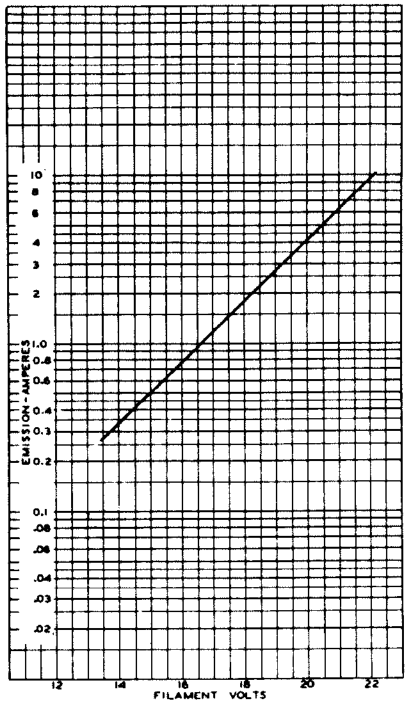
V = 22 VOLTS
A = 60 AMPERES

WITH TWO-PHASE (QUARTER PHASE) A-C EXCITATION



V = 11 VOLTS
A = 60 AMPERES

AVERAGE FILAMENT EMISSION CHARACTERISTIC



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SCHENECTADY, N.Y.

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

7-43 (2500) Superseding GEH-1120A
Filing No. 8850

GENERAL ELECTRIC

Transmitting Tube GL-891-R - - Installation and Operation

Installation

The handling of the 891-R in transportation and storage requires great care, since the tube may be permanently damaged if subjected to sudden jars. Each 891-R is suspended within its shipping crate so that it will not come in contact with the sides of the crate during shipment. The tube should be stored in the crate with the filament end up and should be protected from moisture and extreme temperature changes. Furthermore, while the tube is being handled, it should be kept in a vertical position with the filament end up. Under no circumstances should crated tubes be piled on top of one another. The wieght of the tube with the air-cooled radiator is 40 pounds uncrated and approximately 90 pounds crated.

It is recommended that the tube be tested upon receipt in the equipment in which it is to be used. Before the tube is placed in operation, care should be taken that the glass bulb, and particularly the entrant glass area around the filament leads, is free from foreign matter. These leads become so hot during operation that any paper, shavings, or excelsior, not removed from the stem, may become charred and cause puncture of the bulb. An air blast is recommended for removing such material.

The mounting of the 891-R requires the use of the permanently fitted air-cooled radiator. Supplementary equipment includes a grid-terminal connector and several filament-terminal connectors. The connectors usually are part of the transmitter equipment. The tube should be supported in a vertical position with the glass end up. If the 891-R is subjected to appreciable vibration in service, it is advisable to support the mounting frame, or the mounting itself, by springs. The installation of all wires and connectors must be made so that they will not be close to or touch the bulb. This precaution is necessary in order to avoid almost certain puncture of the glass from corona discharge. Connections to the grid and filament connectors must have some degree of flexibility in order not to put a stress on the grid-cap terminal clamps before they are placed in position. When the leads are soldered to the clamps, a hard type solder should be used. This solder should remain firm at temperatures of 250 C, or more. When the clamps are in place, carefully tighten the setscrews to insure good electrical contact. Connections should never be soldered directly to the tube terminal posts as the heat of the soldering operation may result in the cracking of the seal. The grid terminal cap should not be used to support coils, condensers, chokes, or other circuit parts.

The cooling of the 891-R is accomplished by means of an air-cooled fin radiator which is permanently fitted to the plate at the factory. This radiator must be cooled by means of a vertical air blast of 400 to 600 cubic feet per minute. The temperature of the cooling air should not exceed 45 C. The air-cooling system should be properly installed to insure safe operation of the tube under all conditions and for this reason should be electrically interconnected with the filament and plate supply to prevent the application of voltages to the tube without suitable cooling. Air-pressure interlocks which open the circuit breakers of the filament- and plate-power transformers, are necessary for protecting the tube when the air flow is insufficient or ceases. The radiator is equipped with two wells, one of which is for the insertion of a thermometer to indicate the radiator temperature.

The tungsten filament of the 891-R is of the double-unit type. One end of each unit is brought out of the tube to a common terminal. The other two ends are brought out to separate terminals. The common terminal of the base is larger in diameter than the two end ter-

minals. By proper filament connection, this arrangement makes possible the operation of the filament from two-phase and single-phase alternating current, as well as from direct current. See page 6. For normal operation, each filament unit requires a filament voltage of 11 volts at a current of 60 amperes. The grid and plate returns should be connected to one side of the filament supply when direct current is used, to the center tap of the filament transformer when a single-phase a-c supply is used, and through a balancing resistor to the mid-point of each secondary coil of a two-phase transformer when a two-phase a-c supply is used. When direct current is used, the polarity of the filament leads should be reversed every 500 hours of operation. The filament should be operated at constant voltage rather than constant current and must be allowed to reach at least 80 per cent normal voltage before plate voltage is applied. Intermittent power supply interruptions may be allowed provided the time off does not exceed one second. If the tube is to be used at relatively low output, the plate current will be less than normal, requiring less than normal emission of the filament. The filament, therefore, may be operated at a voltage slightly lower than rated voltage, giving longer life. The permissible reduction in filament voltage may be checked by reducing the filament voltage with the transmitter under normal operation to a value where reduction in output or increase in distortion can just be detected. The filament voltage must then be increased by an amount equivalent to the maximum percentage regulation of the filament supply voltage. Care must be taken that sufficient emission is provided. Otherwise, instability of operation or excessive distortion may be experienced, or the rated plate dissipation of the tube may be exceeded. From the viewpoint of tube life it is usually economically advantageous to provide good regulation of the filament voltage. For example, if the filament is operated continuously at 6 per cent above normal voltage, the evaporation life will be reduced to approximately one half. The filament voltmeter should be connected to indicate voltage at the filament terminals. Since the filament current of the 891-R is very high, the filament connectors should be large and make good contact. The filament base of the 891-R should not be connected to ground or to any part of the circuit.

A <u>filament starter</u> should be used to raise the filament voltage gradually and to limit the high initial rush of current through the filament when the circuit is first closed. The starter may be either a system of time-delay relays cutting resistance out of the circuit, a high-reactance filament transformer, or a simple rheostat. Regardless of the method of control, it is important that the filament current per unit never exceed, even momentarily, a value of 120 amperes. Whenever the filament voltage is turned off, it is advisable to reduce the voltage gradually in steps over a period of two to three minutes. This precaution is necessary to avoid undue mechanical tension and premature filament breakage caused by the difference in cooling rate of the heavy filament center post and the thin filament strands.

The plate circuit should be provided with a time-delay relay which will prevent the application of plate voltage until the filament has reached normal operating temperature.

When the apparatus in which the tube is used is to be idle for periods not exceeding two hours, voltage should be maintained on the filament. However, if desired, provision may be made to reduce the filament voltage to approximately 80 per cent of the rated value during "stand-bys." Where stand-by periods exceed two hours the filament voltage may be removed.

<u>The maximum radiator temperature must not be exceeded under any condition</u>. Air-pressure interlocks which prevent the application of plate and filament voltages under conditions of inadequate air supply should be provided.

Overheating of the 891-R by severe overload may impair its vacuum. Unless the overload has liberated a large amount of gas, it is often possible to degasify the tube by operating it as an r-f power amplifier or oscillator at reduced plate voltage. The first step in the process should be a short period of operation at a plate voltage of 5000 volts or less. The voltage may then be raised in steps of about 2000 volts un-

til the normal operating voltage is attained. At each new voltage, the tube should be operated long enough to insure the attainment of stable conditions.

In order to prevent excessive plate-current flow and the resultant overheating, the ground lead of the plate circuit should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to open the circuit breakers in the primary of the rectifier transformer at slightly higher than normal plate current. The total time required for the operation of the relay and circuit breakers should be about one-tenth second and not more than one-sixth second. A voltage-dropping resistor should be connected permanently in series with the plate lead of each tube for protection of the tube during the time required for the protective relay and circuit breaker to act. The minimum value of this resistor which will give adequate protection with minimum power loss is as follows:

Series Resistor	25	50	200	250	275	300	Ohms
Maximum Power Output of Rectifier	16	40	100	250	640	1600	Kw

Precautions must be taken so that no high capacitance is connected directly across the tube in any manner such that a disturbance within the tube will discharge appreciable energy from the capacitor.

Suitable meters should be provided for the reading of filament voltage, d-c plate voltage, d-c grid voltage, d-c plate current, d-c grid current, and r-f grid current, as well as for the recording of tube life (hours of operation). In addition to the use of meters for indicating suitable operating conditions, their use is also of value in making transmitter adjustments. <u>In modulated service, a cathode-ray oscillograph is recommended to assist in the making of final adjustments for optimum performance</u>. Under no conditions should the maximum values given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS be exceeded.

Heavy leads and conductors together with suitable insulation should be used in all parts of the r-f plate tank circuit so that the losses due to the r-f voltages and currents may be kept at a minimum. Because proper circuit design becomes very important at the higher frequencies, short, heavy leads and circuit returns are essential in order to minimize lead inductance and losses.

When an 891-R is first placed in operation, care should be taken to see that the air-cooling system is functioning properly. The tube should then be operated without plate voltage for five minutes at rated filament voltage. After this initial preheating schedule, the plate voltage can be applied. Start with not more than one-half the usual operating voltage and then carefully increase it in steps of about 2000 volts over a period of approximately 15 minutes to the desired value. The tube should then be operated under the normal load conditions for a period of one hour or more. The plate voltage is usually varied by means of primary taps on the plate transformer. The plate-circuit relay should be open when the transformer primary taps are changed in order to avoid dangerous voltage surges. It is recommended that every three months spare tubes be given the preheating and initial operation schedule as discussed above. This will insure that only good tubes are carried in stock.

In order that the maximum ratings given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS will not be exceeded, changes in plate and filament voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus must be determined. An average value of plate- and filament-supply voltage should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

<u>When a new circuit is tried or when adjustments are made, the plate voltage should be reduced to one-half the rated value to prevent damage to the tube or associated apparatus</u>. After correct adjustment has been made with the tube operating smoothly and without excessive heating, the plate voltage may be raised in several steps to the desired value. Adjustments should be made at each step for optimum operation.

Protective devices are essential for the 891-R, as in the case of other power equipment of high capacity, and

are summarized as follows: Air-pressure interlocks which open the circuit breakers in the primary circuits of the filament- and plate-power transformers, are necessary for protecting the tube when the cooling system fails. A time-delay relay should be used in the plate circuit to prevent application of plate voltage until the filament has reached at least 80 per cent normal voltage. The ground lead of the plate circuit should be provided with an instantaneous overload relay to prevent excessive plate current and tube overheating. In addition to the latter precaution, a voltage-dropping resistor should be connected permanently in series with the plate lead to protect the tube during the time required for the protective relay and circuit breaker to act.

The rated plate voltage of the 891-R is extremely dangerous to the user. Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which are at a high potential above ground, should be enclosed in a protective housing. This housing may be of fibre or similar insulating material. If metal housing is used, care should be taken that it does not absorb excessive power. The protective housing should be designed with automatic interlocks so that the operating personnel cannot possibly come in accidental contact with any high-voltage point in the electrical system. These interlock devices should function to break the primary circuit of the plate-voltage supply when any gate or door on the protective housing is opened, and should prevent the closing of this primary circuit until the door is again locked.

Operation

As a Class A audio-frequency amplifier or modulator, the 891-R is capable of delivering approximately 2000 watts of audio-frequency power with very low distortion. Typical operating conditions are shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS. Grid bias for a single tube in Class A service may be obtained from a separate voltage source or by means of a cathode-bias resistor shunted by a condenser large enough to minimize degenerative effects at low audio frequencies.

If more audio output is desired than can be obtained from a single 891-R, two or more 891-R's may be operated in parallel or in push-pull. For example, two tubes in parallel provide twice the output of a single tube without an increase in grid-signal voltage. The push-pull connection will give slightly more than double the power output of a single tube that requires twice the grid-signal voltage. The push-pull arrangement has the advantage of balancing out the even-order harmonics from the output. If the tubes are operated in parallel, a non-inductive resistance of 10 to 100 ohms should be placed in series with each grid lead, as close to the tube as possible, in order to prevent parasitic oscillations. When the parallel or the push-pull connection is used, each grid circuit should be provided with a separate grid-bias adjustment in order to balance the grid and plate current.

In cases where the input circuit of the 891-R is resistance-coupled or impedance-coupled, the resistance in the grid circuit should not be made too high. A resistance value of 100,000 ohms for one 891-R is the recommended maximum when cathode bias is used; without cathode bias, the grid resistance should not exceed 50,000 ohms.

As a Class B modulator or audio-frequency amplifier, two 891-R's are used in a balanced circuit, each tube amplifying only half the time. The input transformer should be designed to give good frequency response when operated into an open circuit, such as that represented by the grid circuit of the Class B stage when the signal amplitude is small. It should be designed to handle the required input power for a strong signal. The output transformer should be designed so that the resistance load presented by the modulated Class C amplifier is reflected as a plate-to-plate load of 8400 ohms in the Class B stage for the 10,000-volt conditions. It should have a core sufficiently large to avoid saturation effects which would impair the quality of the output. Grid bias for the 891-R in Class B a-f service should be obtained from a generator or other d-c source of excellent regulation. It should not be obtained from a high-resistance supply such as a grid leak, nor from a rectifier, unless the latter has exception-

ally good voltage regulation. Each grid circuit should be provided with a separate grid-bias adjustment in order to balance the grid and plate current.

As a <u>Class B radio-frequency amplifier</u>, the 891-R may be used as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS. In Class B r-f service, the plate is supplied with unmodulated d-c voltage. The grid is excited by r-f voltage modulated at audio frequency in one of the preceding stages and the power output is proportional to the square of the grid-excitation voltage. Under these conditions, the plate dissipation is greatest when the carrier is unmodulated. Grid bias should be obtained from a generator, from a rectifier of excellent regulation, or from a cathode-bias resistor, suitably by-passed for audio and radio frequencies.

As a <u>plate-modulated Class C radio-frequency amplifier</u>, the 891-R may be used as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS. Grid bias for this service may be obtained from a grid leak of 20,000 ohms, or from a suitable combination of either grid leak and fixed supply, or grid leak and cathode-bias resistor. The cathode-bias resistor should be suitably by-passed for audio and radio frequencies. The combination-bias methods are particularly desirable because distortion effects are minimized by bias-supply compensation. Grid-bias voltage for Class C service is not particularly critical so that correct adjustment may be obtained with values differing widely from those indicated for this service.

As a <u>Class C radio-frequency amplifier and oscillator for telegraph service</u>, the 891-R may be used as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS. Grid bias for this service may be obtained from a grid leak of 20,000 to 30,000 ohms, from a generator, from a rectifier, or from a cathode-bias resistor (preferably variable) suitably by-passed for radio frequencies. The cathode-bias method is advantageous due to the fact that the grid bias is automatically regulated in direct proportion to the sum of the plate and the grid current and that there is little chance of the plate current becoming dangerously high, even if the r-f grid excitation is removed. Grid-leak bias has the advantage of simplicity and of automatically biasing the grid in proportion to the excitation voltage available. The use of protective devices (see INSTALLATION) designed to open the plate circuit on excessive rises of plate current minimizes danger of overload. Since grid-bias voltage for Class C service is not particularly critical, correct circuit adjustment may be obtained with values differing widely from those indicated for this service.

The <u>grid circuit</u> must be so arranged that it is impossible for high voltages to be established between the grid and filament at any frequency except the fundamental in order to prevent parasitic oscillations. The grid voltage at the fundamental frequency should be sufficient to provide only the necessary grid excitation for the tube. Because of the high current carried by the grid lead and its adjoining circuit, heavy conductors carefully connected should be used.

<u>The d-c grid current and the r-f grid current should never exceed the values given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS</u>. Operating values will vary with individual tubes and circuits.

The 891-R may be operated at maximum ratings in all classes of service at frequencies up to 1.5 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised. (Other maximum ratings are the same as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.) The tabulation* shows the highest percentage of maximum plate voltage and power input that can be used at 1.5, 7.5, and 20 mc for any class of service. Special attention should be given to adequate cooling and the maintenance of normal ambient temperatures at these frequencies.

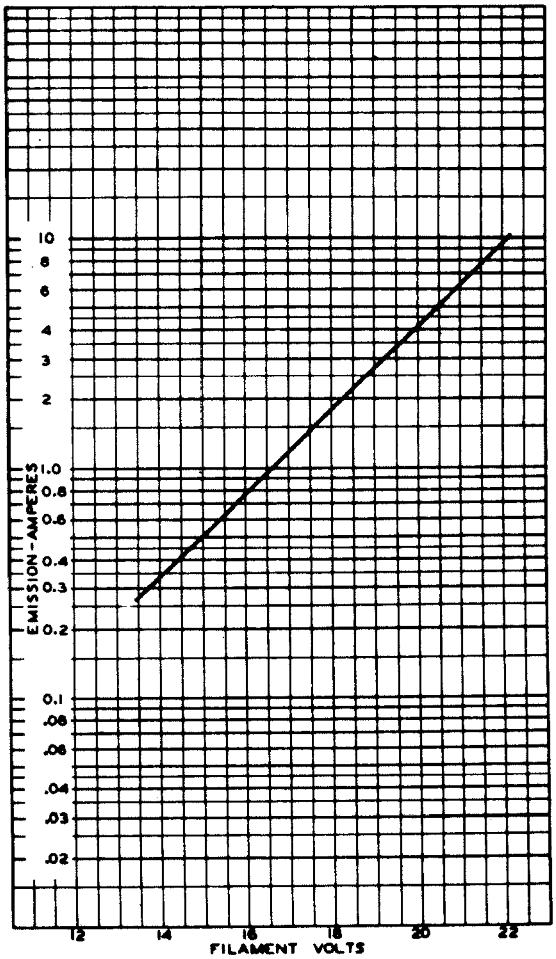
If more radio-frequency power output is required than can be obtained from a single 891-R, the push-pull or the parallel connection may be used. For example, two tubes connected in push-pull or in parallel will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage; the

*See Description and Rating Sheet

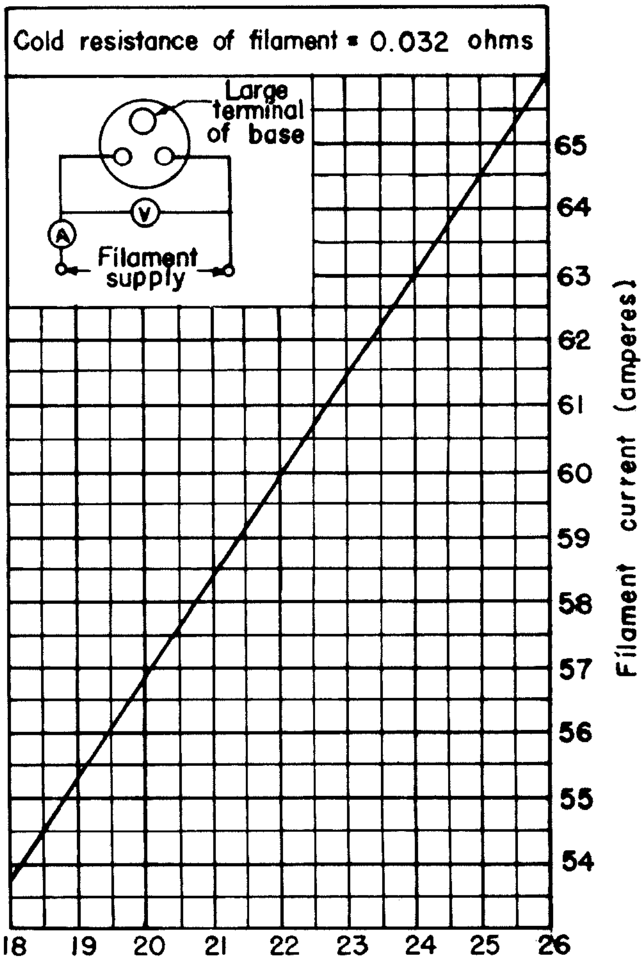
push-pull connection requires twice the r-f excitation voltage necessary to drive a single tube. With either connection the driving power required is approximately twice that for single-tube operation while the grid bias is the same as for a single tube. The push-pull arrangement has the advantage of balancing the circuit with respect to ground and of canceling the even-order harmonics from the output. When the parallel connection is used, a non-inductive resistor of 10 to 100 ohms and a choke coil or other suitable network should be placed in series with the grid lead of each tube, as close to the tube as possible, in order to prevent parasitic oscillations. With either connection, it is preferable to provide for a separate grid-bias or grid-excitation adjustment in order to balance the grid and the plate current.

Careful handling and conservative operation of the 891-R will result in longer life and more satisfactory performance.

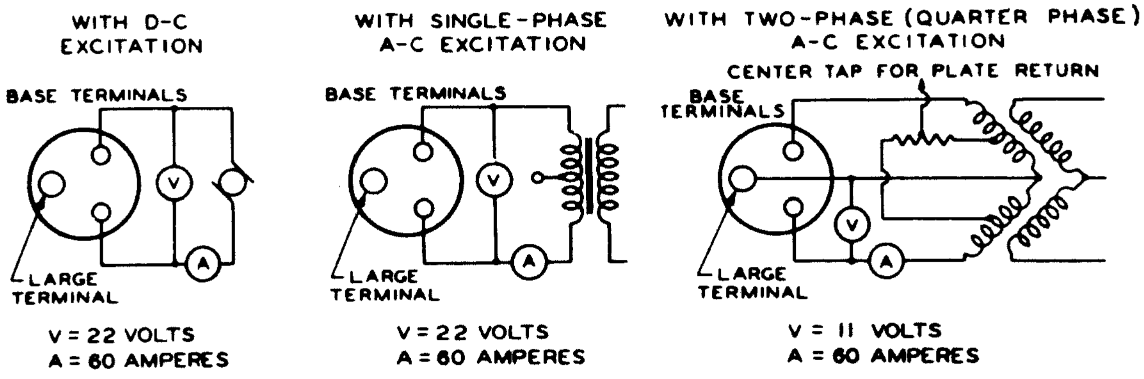
AVERAGE FILAMENT EMISSION CHARACTERISTIC



Average filament characteristic



FILAMENT CONNECTIONS



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Transmitting Tube GL-891—Installation and Operation

Installation

The handling of the 891 in transportation and storage requires great care, since the tube may be permanently damaged if subjected to sudden jars. Each 891 is suspended within its shipping crate so that it will not come in contact with the sides of the crate during shipment. The tube should be stored in the crate with the filament end up and should be protected from moisture and extreme temperature changes. Furthermore, while the tube is being handled, it should be kept in a vertical position with the filament end up. Under no circumstances should crated tubes be piled on top of one another. The weight of an 891, crated for shipment, is approximately 10 pounds; uncrated, approximately 3 pounds.

It is recommended that the tube be tested upon receipt in the equipment in which it is to be used. Before the tube is placed in operation, care should be taken that the glass bulb, and particularly the entrant glass area around the filament leads, is free from foreign matter. These leads become so hot during operation that any paper, shavings, or excelsior, not removed from the stem, may become charred and cause puncture of the bulb. An air blast is recommended for removing such material.

The mounting of the 891 requires the use of the water jacket, UT-1285-A. The tube should be supported in a vertical position with the glass end up. If the 891 is subjected to appreciable vibration in service, it is advisable to support the water jacket by springs. When concrete basework is provided for the transmitter and when machines or other sources of vibration are not present, it is unnecessary to use spring suspension. The installation of all wires and connections must be made so that they will not be close to or touch the bulb. This precaution is necessary in order to avoid almost certain puncture of the glass from corona discharge.

The 891 should be placed in its water jacket very carefully and then firmly fastened. It is advisable to secure the tube in its jacket before making the electrical connections. When the jacket-clamping device is tightened, the clamping screws must seat properly on top of the tube flange. Proper seating will be obtained by the use of the standard gasket, PX-1178, which is supplied with each tube. The clamping screws should be tightened securely with the fingers. Do not tighten with a wrench, pliers or any other tool. Be sure that the ears of the clamping screws do not protrude above the top of the corona shield. The ears are mounted on pins so that they can be swung down out of the way. If these precautions are not taken, the tube may be ruined by a glass crack caused by improper seating of the clamps, or by puncture of the bulb by corona discharge from the ears of the clamping screws. The grid and filament leads should not be taut, but should allow for some movement in order to avoid placing a strain on the glass bulb. Before a readjustment of either the tube or its jacket is made, the leads should be disconnected. The retaining lugs, threads, and moving parts of the jacket may be kept from rusting and sticking by coating them with a thin film of oil or oildag. Do not use an adhesive to seal the jacket against leaks because any sticking of the plate in the jacket may cause the tube to be damaged during its removal.

When the 891 is removed from its water-cooling jacket, first be sure that the temperature of the grid and filament is below red heat. Then completely release the locking device and carefully remove the tube. Should sticking occur, twist the tube gently back and forth, at the same time raising it carefully. Never use force when the tube is removed.

The water-cooling system for the plate of the 891 consists, in general of a source of cooling water, a water jacket insulated from ground, and a feed-pipe system which carries the water to and from the jacket. A pump is used to circulate the water through the system. Rubber hose of good insulating quality, or ceramic coil units, should be employed to carry the water from a grounded point in the pipe to and from the jacket. Installation requirements

for the rubber hose and ceramic coil units are the same. The length of the inlet and outlet sections of the hose or tubing should be not less than 15 feet each so that the water column contained therein has a resistance high enough to reduce the leakage current to a negligible value. Proper functioning of the water-cooling system is of the utmost importance. Even a momentary failure of the water flow will damage the tube. In fact, without cooling water, the heat of the filament alone is sufficient to cause serious harm. It is necessary, therefore, to provide a method for preventing operation of the tube during such an emergency. This may be accomplished by the use of water-flow circuit breakers, or interlocks, which open the circuit breakers in the primary circuits of the filament and plate power transformers whenever the water flow is insufficient or ceases. An outlet-water thermometer and a water-flow meter are necessary to determine the water temperature and the water flow, respectively. A combination interlock and flow meter may be used if desired. With a properly designed and clean water jacket, a water flow of 3 to 8 gallons per minute, depending on operating conditions, is required to cool the plate. The cooling water should flow in at the bottom of the jacket and out at the top, in order to avoid air traps in the jacket. <u>The temperature of the water at the jacket outlet must not exceed 70 C. The water must not be allowed to boil and the flow must be great enough to prevent the formation of steam bubbles on the plate surface</u>. The formation may occur even at a lower temperature due to the focusing effect of the grid. It may be detected by the use of an improvised stethoscope which may consist of six feet of high-grade insulating tubing. The stethoscope is pressed against the jacket at various points while suitable listening observations are made. The test for boiling water should be made each time the tube is adjusted.

Distilled water is recommended for cooling because it greatly reduces the probability of scale formation. Scale is usually very hard and appears as a light-colored deposit on the plate during life. Scale prevents adequate cooling of the tube because it hinders proper transfer of heat from the plate to the water. The mineral content, flow, heat dissipation, temperature, etc., of undistilled water is so varied that no specific recommendations to prevent scale can be made. In any case, a sample of the cooling water should be analyzed before plans are made for the water system. In general, water which shows a hardness greater than 10 grains per gallon, or a resistivity of less than 4000 ohms per cubic centimeter, should not be used. Regardless of the kind of water used, the system should be kept free from accumulation of foreign material. A 10 per cent solution of hydrochloric acid will ordinarily dissolve scale in emergency cases. After such treatment, the plate should be carefully rinsed. Since the tube must be removed from its jacket for this treatment and since frequent removals are objectionable because of danger from accidental breakage, the best insurance against tube failure due to scale is the complete elimination of the cause of scale.

The tungsten <u>filament</u> of the 891 is of the double-unit type. One end of each unit is brought out of the tube to a common terminal. The other two ends are brought out to separate terminals. The common terminal of the base is larger in diameter than the two end terminals. By proper filament connection, this arrangement makes possible the operation of the filament from two-phase and single-phase alternating current, as well as from direct current. See page 7. For normal operation, each filament unit requires a filament voltage of 11 volts at a current of 60 amperes. The grid and plate returns should be connected to one side of the filament supply when direct current is used, to the center tap of the filament transformer when a single-phase a-c supply is used, and through a balancing resistor to the midpoint of each secondary coil of a two-phase transformer when a two-phase a-c supply is used. When direct current is used, the polarity of the filament leads should be reversed every 500 hours of operation. The filament should be operated at constant voltage rather than constant current and must be allowed to reach at least 80 per cent normal voltage before plate voltage is applied.

Intermittent power supply interruptions may be allowed provided the time off does not exceed one second. If the tube is to be used at relatively low output, the plate current will be less than normal, requiring less than normal emission of the filament. The filament, therefore, may be operated at a voltage slightly lower than rated voltage, giving longer life. The permissible reduction in filament voltage may be checked by reducing the filament voltage with the transmitter under normal operation to a value where reduction in output or increase in distortion can just be detected. The filament voltage must then be increased by an amount equivalent to the maximum percentage regulation of the filament supply voltage. Care must be taken that sufficient emission is provided. Otherwise, instability of operation or excessive distortion may be experienced, or the rated plate dissipation of the tube may be exceeded. From the viewpoint of tube life it is usually economically advantageous to provide good regulation of the filament voltage. For example, if the filament is operated continuously at 6 per cent above normal voltage, the evaporation life will be reduced to approximately one half. The filament voltmeter should be connected to indicate voltage at the filament terminals. Since the filament current of the 891 is very high, the filament connectors should be large and make good contact. The filament base of the 891 should not be connected to ground or to any part of the circuit.

A <u>filament starter</u> should be used to raise the filament voltage gradually and to limit the high initial rush of current through the filament when the circuit is first closed. The starter may be either a system of time-delay relays cutting resistance out of the circuit, a high-reactance filament transformer, or a simple rheostat. Regardless of the method of control, it is important that the filament current per unit never exceed, even momentarily, a value of 120 amperes. Whenever the filament voltage is turned off, it is advisable to reduce the voltage gradually in steps over a period of two to three minutes. This precaution is necessary to avoid undue mechanical tension and premature filament breakage caused by the difference in cooling rate of the heavy filament center post and the thin filament strands.

The plate circuit should be provided with a time-delay relay which will prevent the application of plate voltage until the filament has reached normal operating temperature.

When the apparatus in which the tube is used is to be idle for periods not exceeding 2 hours, voltage should be maintained on the filament. However, if desired, provision may be made to reduce the filament voltage to approximately 80 per cent of the rated value during "stand-bys."

Overheating of the 891 by severe overload may impair its vacuum. Unless the overload has liberated a large amount of gas, it is often possible to degasify the tube by operating it as an r-f power amplifier or oscillator at reduced plate voltage. The first step in the process should be a short period of operation at a plate voltage of 5000 volts or less. The voltage may then be raised in steps of about 2000 volts until the normal operating voltage is attained. At each new voltage, the tube should be operated long enough to insure the attainment of stable conditions.

<u>The plate dissipation of the 891 should never exceed the values given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.</u> The approximate plate dissipation values may be calculated from the following expression:

$$P_{kilowatts} = \frac{n\,(t_o - t_1)}{4}$$

In which (t_1) is the known initial temperature of the cooling water in centigrade degrees (t_o) the temperature of the water at the water jacket outlet in centigrade degrees, and (n) the number of gallons of water per minute of flow.

In order to prevent excessive plate-current flow and the resultant overheating, the ground lead of the plate circuit should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to open the circuit breakers in the primary of the rectifier transformer at slightly higher than normal plate current. The total time required for the operation of the relay and circuit breakers should be about one-tenth sec-

ond and not more than one-sixth second. A voltage-dropping resistor should be connected permanently in series with the plate lead of each tube for protection of the tube during the time required for the protective relay and circuit breaker to act. The minimum value of this resistor which will give adequate protection with minimum power loss is as follows:

SERIES RESISTOR	25	50	200	250	275	300	Ohms
MAX POWER OUTPUT OF RECTIFIER	16	40	100	250	640	1600	Kilowatts

Precautions must be taken so that no high capacitance is connected directly across the tube in any manner such that a disturbance within the tube will discharge appreciable energy from the capacitor.

When more than one 891 is used in a circuit, a minimum space allowance of at least 4 inches between tubes should be provided for adequate ventilation. Free circulation of cool air around the glass bulb should be maintained. High-temperature air from other apparatus in the circuit should be prevented from circulating around the tubes. The necessity for generous spacing between tubes and the free circulation of cool air becomes of greater importance when the 891 is used at the higher frequencies.

Suitable meters should be provided for the reading of filament voltage, d-c plate voltage, d-c grid voltage, d-c plate current, and d-c grid current, as well as for the recording of tube life (hours of operation). When the 891 is operated at the higher radio frequencies, it is also necessary to employ a radio-frequency ammeter in the grid circuit. In addition to the use of meters for indicating suitable operating conditions, their use is also of value in making initial transmitter adjustments. However to assist in the making of final adjustments for optimum performance, it is recommended that a cathode-ray oscillograph be used. Under no conditions should the maximum values given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS be exceeded.

Heavy leads and conductors together with suitable insulation should be used in all parts of the r-f plate tank circuit so that the losses due to the r-f voltages and currents may be kept at a minimum. Since proper circuit design becomes very important at the higher frequencies, it is essential that short, heavy leads and circuit returns are used in order to minimize lead inductance and losses.

When an 891 is first placed in operation, care should be taken to see that the water-cooling system is functioning properly. The tube should then be operated without plate voltage for 5 minutes at rated filament voltage. After this initial preheating schedule, the plate voltage can be applied. Start with not more than one-half the usual operating voltage and then carefully increase it in steps of about 2000 volts over a period of approximately 15 minutes to the desired value. The tube should then be operated under the normal load conditions for a period of not less than two hours. The plate voltage is usually varied by means of primary taps on the plate transformer. The plate-circuit relay should be open when the transformer primary taps are changed in order to avoid dangerous voltage surges. It is recommended that every three months spare tubes be given the preheating and initial operation schedule as discussed above. This will insure that only good tubes are carried in stock.

In order that the maximum ratings given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS will not be exceeded, changes in plate and filament voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus, must be determined. An average value of plate- and filament-supply voltage should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced to one-half the rated value to prevent damage to the tube or associated apparatus. After correct adjustment has been made with the tube operating smoothly and without excessive heating, the plate voltage may be raised in several steps to the desired value.

Adjustments should be made at each step for optimum operation.

Protective devices are essential for the 891, as in the case of other power equipment of high capacity, and are summarized as follows: Water-circuit breakers, or interlocks which open the circuit breakers in the primary circuits of the filament and plate power transformers, are necessary for protecting the tube when the cooling system fails. A time-delay relay should be used in the plate circuit to prevent application of plate voltage until the filament has reached normal operating temperature. The ground lead of the plate circuit should be provided with an instantaneous overload relay to prevent excessive plate current and tube overheating. In addition to the latter precaution, a voltage-dropping resistor should be connected permanently in series with the plate lead to protect the tube during the time required for the protective relay and circuit breaker to act.

The rated plate voltage of the 891 is extremely dangerous to the user. Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which are at a high potential above ground, should be enclosed in a protective housing. This housing may be of fibre or similar insulating material. If metal housing is used, care should be taken that it does not absorb excessive power. The protective housing should be designed with automatic interlocks so that the operating personnel cannot possibly come in accidental contact with any high-voltage point in the electrical system. These interlock devices should function to break the primary circuit of the plate-voltage supply when any gate or door on the protective housing is opened, and should prevent the closing of this primary circuit until the door is again locked.

Operation

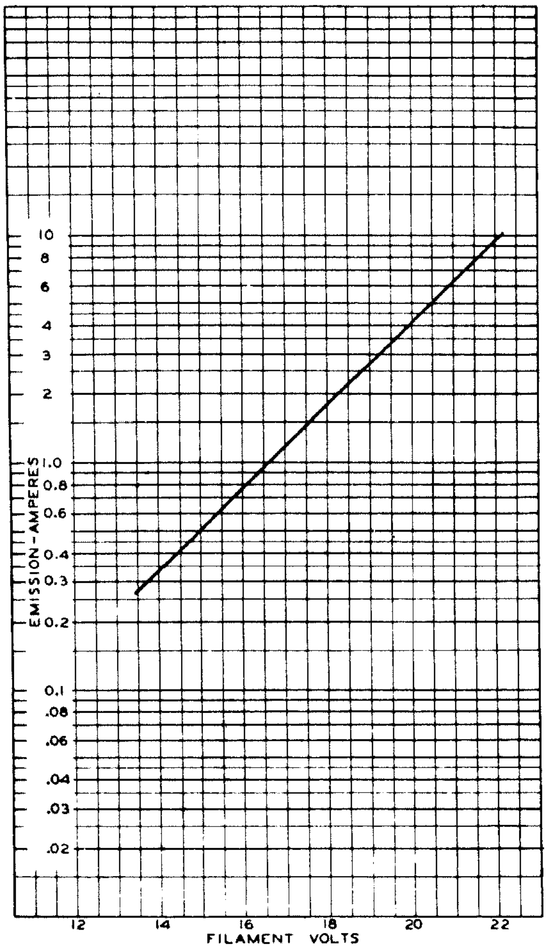
As a Class A audio-frequency amplifier or modulator, the 891 is capable of delivering approximately 2000 watts of audio-frequency power with very low distortion. Typical operating conditions are shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS. Grid bias for a single tube in Class A service may be obtained from a separate voltage source or by means of a cathode-bias resistor shunted by a condenser large enough to minimize degenerative effects at low audio frequencies.

If more audio output is desired than can be obtained from a single 891, two or more 891's may be operated in parallel or in push-pull. For example, two tubes in parallel provide twice the output of a single tube without an increase in grid-signal voltage. The push-pull connection will give slightly more than double the power output of a single tube but requires twice the grid-signal voltage. The push-pull arrangement has the advantage of balancing out the even-order harmonics from the output. If the tubes are operated in parallel, a noninductive resistance of 10 to 100 ohms should be placed in series with each grid lead, as close to the tube as possible, in order to prevent parasitic oscillations. When the parallel or the push-pull connection is used, each grid circuit should be provided with a separate grid-bias adjustment in order to balance the grid and plate currents.

In cases where the input circuit of the 891 is resistance-coupled or impedance-coupled, the resistance in the grid circuit should not be made too high. A resistance value of 100,000 ohms for one 891 is the recommended maximum when cathode bias is used. Without cathode bias, the grid resistance should not exceed 50,000 ohms.

As a Class B modulator or audio-frequency amplifier, two 891's are used in a balanced circuit, each tube amplifying only half the time. The input transformer should be designed to give good frequency response when operated into an open circuit, such as that represented by the grid circuit of the Class B stage when the signal amplitude is small. It should also be designed to handle the required input power for a strong signal. The output transformer should be designed so that the resistance load presented by the modulated Class C amplifier is reflected as a plate-to-plate load of 10,000 ohms in the Class B stage for the 12,500-volt conditions. It should have a core sufficiently large to avoid saturation ef-

AVERAGE FILAMENT EMISSION CHARACTERISTIC



fects which would impair the quality of the output. If the secondary is to carry the d-c plate current of the modulated amplifier, the core should be made larger and include an air gap to compensate for the d-c magnetization current. Grid bias for the 891 in Class B a-f service should be obtained from a generator or other d-c source of excellent regulation. It should not be obtained from a high-resistance supply such as a grid leak, nor from a rectifier, unless the latter has exceptionally good voltage regulation. Each grid circuit should be provided with a separate grid-bias adjustment in order to balance the grid and plate currents.

As a Class B radio-frequency amplifier, the 891 may be used as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS. In Class B r-f service, the plate is supplied with unmodulated d-c voltage. The grid is excited by r-f voltage modulated at audio-frequency in one of the preceding stages and the power output is proportional to the square of the grid-excitation voltage. Thus, the plate dissipation is greatest when the carrier is unmodulated. Grid bias should be obtained the same as for Class B a-f service.

As a plate-modulated Class C radio-frequency amplifier, the 891 may be used as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS. Grid bias for this service may be obtained from a grid leak of 20,000 to 30,000 ohms, or from a suitable combination of either grid leak and fixed supply, or grid leak and cathode bias resistor. The cathode-bias resistor should be suitably by-passed for audio and radio frequencies. The combination-bias methods are particularly desirable because distortion effects are minimized by bias-supply compensation. Grid-bias voltage for Class C service is not particularly critical so that correct adjustment may be obtained with values differing widely from those indicated for this service.

As a Class C radio-frequency amplifier and oscillator for telegraph service, the 891 may be used as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS. Grid bias for this service may be obtained from a grid leak of 20,000 to 30,000 ohms, from a generator, from a rectifier, or from a cathode-bias resistor (preferably variable) suitably by-passed for radio frequencies. The cathode-bias method is advantangeous due to the fact that the grid-bias is automatically regulated in direct proportion to the sum of the plate and the grid current and that there is little chance of the plate current becoming dangerously high, even if the r-f grid excitation is removed. Grid-leak bias has the advantage of simplicity and of automatically biasing the grid in proportion to the excitation voltage available. The use of protective devices (see INSTALLATION) designed to open the plate circuit on excessive rises of plate current minimizes danger of overload. Since grid-bias voltage for Class C service is not particularly critical, correct circuit adjustment may be obtained with values differing widely from those indicated for this service.

The grid circuit, in order that parasitic oscillations may be prevented,

must be so arranged that it is impossible for high voltages to be established between the grid and filament at any frequency except the fundamental. The grid voltage at the fundamental frequency should be sufficient to provide only the necessary grid excitation for the tube. Because of the high current carried by the grid lead and its adjoining circuit, heavy conductors carefully connected, should be used.

The d-c grid current and the r-f grid current should never exceed the values given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS. Operating values will vary with individual tubes and circuits.

The 891 may be operated at maximum ratings in all classes of service at frequencies up to 1.5 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS). The tabulation* shows the highest percentage of maximum plate voltage and power input that can be used at 1.5, 7.5 and 20 mc for any class of service. Special attention should be given to adequate cooling and the maintenance of normal ambient temperatures at these frequencies.

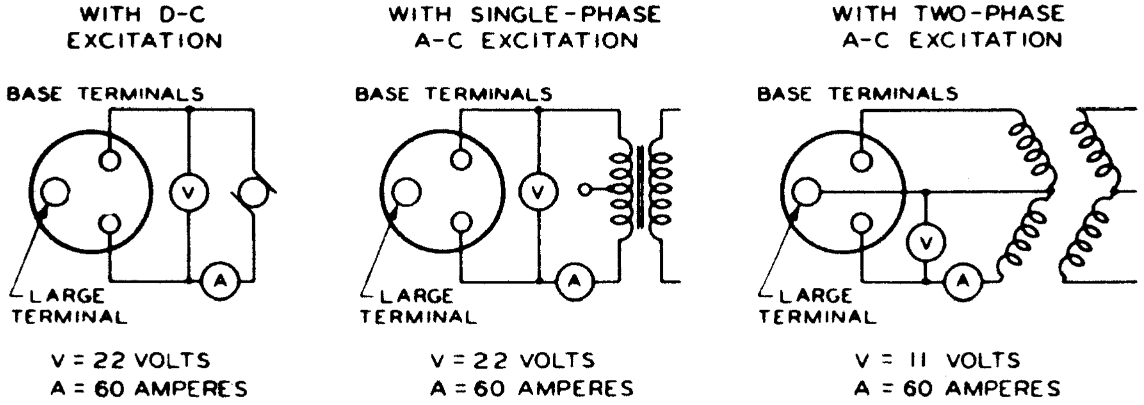
With the grid connected to the plate through the shortest possible connection, the resonant frequency of the grid-plate circuit is approximately 60 megacycles.

If more radio-frequency power output is required than can be obtained from a single 891, the push-pull or the parallel connection may be used. For example, two tubes connected in push-pull or in parallel will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage; the push-pull connection requires twice the r-f excitation voltage necessary to drive a single tube. With either connection the driving power required is approximately twice that for single-tube operation while the grid bias is the same as for a single tube. The push-pull arrangement has the advantage of cancelling the even-order harmonics from the output and of simplifying the balancing of high-frequency circuits. When two or more 891's are operated in parallel, a noninductive resistance of 10 to 100 ohms should be placed in series with the grid lead of each tube, as close to the tube as possible, in order to prevent parasitic oscillations. With either connection, each grid circuit should be provided with a separate grid-bias adjustment in order to balance the grid and plate current.

Careful handling and conservative operation of the 891 will result in longer life and more satisfactory performance.

* See Description and Rating Sheet

FILAMENT CONNECTIONS



GENERAL ELECTRIC

SCHENECTADY, N.Y.

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GENERAL ELECTRIC

Transmitting Tube GL-814 - - Installation and Operation

Installation

MECHANICAL

Mountings must be of good quality and should be so installed as to minimize danger from impact. If the set is subject to vibration a shock-absorbing suspension must be employed.

COOLING

All apparatus should be arranged to allow free circulation of air around the pliotron. The bulb becomes very hot during operation and, therefore, should neither come in contact with any metallic object nor be subjected to drops or spray of liquid.

Sets using more than one tube should provide adequate spacing between tubes so that adjacent portions of the bulbs do not operate appreciably hotter than the other sections.

ELECTRICAL

To avoid danger of corona discharge all wires and connections should be made to allow several inches of free space around the pliotron. For tubes using a metal base the metal shell must not be connected to any part of the circuit.

The filament should be operated preferably from an a-c source, although a d-c supply may be used. The filament voltmeter should be connected to indicate the voltage at the filament terminals. The filament supply should be designed to allow operation at rated filament voltage. The filament voltage should not vary more than ±5% from the rated value. The filament transformer shall have good regulation and should be designed for at least 30 per cent above rated filament wattage.

When the tube is used in intermittent service the filament voltage may be removed for stand-by periods greater than 15 minutes. There should be no reduction of filament voltage for periods of less than five minutes. The filament voltage may be reduced to 80 per cent during periods greater than five minutes if desired.

Overheating by severe overload may decrease filament emission. Unless the overload has liberated a large amount of gas, the activity of the filament usually can be restored by operating the filament at rated voltage for 10 minutes or more with no voltage on the plate or grid. This process may be accelerated by increasing the filament voltage to 20 per cent above the †normal value (not higher) for a few minutes.

The beam-forming plates of the 814 are connected to a separate base pin. They should always be operated at zero potential with respect to

†Note: The ratings and characteristics of a particular pliotron are given on the Description and Rating Sheet for that tube.

the filament; never positive. When the filament is operated from an a-c supply the beam-forming plates should be connected to the midpoint of the filament circuit. When the filament is operated from a d-c supply they should be connected to the negative end of the filament.

The grid-circuit and plate-circuit return leads should be connected to the center tap of the filament-transformer secondary. When d-c filament excitation is used the return leads from the grid and plate circuits should be connected to the negative filament terminal.

The screen voltage may be obtained from a separate source, from a voltage divider, or from the plate supply through a series resistor, depending upon the service in which the tube is used (see OPERATION). When the screen voltage is obtained from a separate source, or from a voltage divider, plate voltage should be applied before or simultaneously with the screen voltage. Otherwise, with voltage on the screen only, the screen current may rise high enough to cause excessive screen dissipation. When screen-voltage regulation is not an important factor, the series-resistance method for obtaining screen voltage is desirable because of its simplicity and because it limits the d-c power input to the screen. The screen should never be allowed to attain a temperature at which it will show color.

The screen current is a very sensitive indication of the plate-circuit loading and rises excessively (often to the point of damaging the tube) when the amplifier is operated without load. Therefore, care should be taken when tuning an 814 under no load conditions in order to prevent exceeding the screen-input rating of the tube.

A protective device, such as a high-voltage fuse, should be used to protect both the plate and screen against overloads. When a voltage divider or a resistor in series with the plate supply is used for obtaining the screen voltage, the protective device should be placed in the common positive high-voltage lead. It should remove the high-voltage supply when the plate current reaches a value 50 per cent greater than normal. When the screen voltage is obtained from a separate source or from a voltage divider of good regulation, a protective device should be placed in the screen-supply lead. It should remove the screen voltage when the d-c screen current reaches a value 50 per cent greater than normal.

An ammeter in the plate circuit of each tube should be connected so that the direct-plate current may be checked regularly.

The circuits should be arranged to prevent parasitic oscillations so that the tube will not be subjected to excessive voltages and currents.

Adequate shielding and isolation of the input circuit and output circuits are necessary if optimum results are to be obtained. In some cases neutralization may be necessary to prevent feedback. The impedance between screen and filament must be kept as low as possible by the use of a by-pass capacitor. The capacitance should be approximately 0.01 uuf; large values may cause excessive a-f by-passing, while small values may cause excessive r-f feedback from plate to control grid, depending upon circuit layout, frequency, and gain.

When a new circuit is tried or when adjustments are made, the screen and plate voltages should be reduced in order to prevent damage to the tube or associated apparatus in case the circuit adjustments are incorrect. It is advisable to use a protective resistance of about 10,000 ohms, total, in series with the screen lead and a protective resistance of 9000 ohms in series with the high-voltage plate lead during such adjustments.

In rating pliotrons certain values are given as maximum; that is, the values beyond which it is unsafe to go from the viewpoint of life and performance. In order not to exceed the †maximum ratings, changes in plate and filament voltage caused by line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus must be determined. Then an average value of plate voltage should be chosen so that under the usual operating conditions the maximum ratings will not be exceeded.

IN TRYING OUT A NEW CIRCUIT OR WHEN ADJUSTMENTS ARE BEING MADE THE PLATE VOLTAGE SHOULD BE REDUCED IN ORDER TO PREVENT DAMAGE TO THE PLIOTRON OR ASSOCIATED APPARATUS IN CASE THE ADJUSTMENTS ARE INCORRECT.

Operation

GENERAL

Maximum ratings and typical operating conditions for each recommended class of service are given on the Description and Rating Sheet covering the individual type of tube. The typical values given must not be considered as ratings, because the tube may be used at any suitable conditions within the maximum ratings.

CLASS B RADIO-FREQUENCY AMPLIFIER

In Class B radio-frequency service the plate is supplied with unmodulated direct voltage, and the grid is excited by modulated r-f voltage. It is important to note that in this service the plate dissipation is greatest when the carrier is unmodulated. Therefore, the circuit should be adjusted so that, without modulation, the plate loss will not exceed the †maximum rating.

Grid bias for Class B a-f or r-f service should be obtained from a battery or other d-c source of good regulation. It should not be obtained from a high-resistance supply such as a grid leak. The screen voltage should be obtained from a separate source or from a voltage divider of good regulation connected across the plate supply.

CLASS C RADIO-FREQUENCY POWER AMPLIFIER - GRID MODULATED

In grid-modulated Class C r-f telephone service the 814 is supplied with unmodulated r-f grid voltage and with d-c grid bias which is modulated at audio frequencies. Grid bias should be obtained from a fixed supply. The screen voltage should be obtained from a separate source or from a voltage divider of good regulation. The audio power required in this service is very small, being sufficient only to meet the peak grid-power requirement of the Class C amplifier on the positive crest of the a-f input signal.

CLASS C RADIO-FREQUENCY POWER AMPLIFIER - PLATE MODULATED

In this type of service the plate supply voltage is modulated so that the tube output is modulated radio frequency.

The maximum ratings and typical operating conditions given in the †Technical Information are such that a modulation factor up to 1.0 may be used. When a lower value of modulation is used, the plate dissipation allowed may be increased, but should be limited so that with the modulation

†Note: The ratings and characteristics of a particular pliotron are given on the Description and Rating Sheet for that tube.

sustained at its peak value the plate loss will not exceed the plate dissipation rating.

The screen voltage should preferably be obtained from a fixed supply. The screen voltage should be modulated simultaneously with the plate voltage and in such a manner that the ratio of screen voltage to plate voltage remains constant. Modulation of the screen voltage can be accomplished either by connecting the screen to a separate winding of the modulation transformer or by connecting it through a blocking condenser to a tap on the modulation transformer or choke. With the latter method an a-f choke of suitable impedance for low frequencies should be connected in series with the screen supply lead. Grid bias may be obtained from a grid resistor or from a combination of either grid resistor and fixed supply or grid resistor and cathode resistor. The combination method of grid resistor and fixed supply has the advantage not only of protecting the tube from damage through loss of excitation but also of minimizing distortion by means of bias-supply compensation.

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR

In telegraph service the plate input power is keyed, i.e., is on and off alternately in accordance with the characters of some code. During the "key-down" periods the tube functions as an unmodulated radio-frequency power amplifier. The tube may be used also as an amplifier or oscillator without keying. In both types of service the ratings given are for "key-down" conditions.

Certain methods of modulation may be applied to this class of service provided the modulation is essentially negative and the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

Grid bias for Class C service may be obtained from a grid leak, from a battery, from a rectifier of good regulation, or from a self-biasing resistor by-passed with a suitable capacitor. With the grid-leak method the grid excitation must not be removed without also removing the plate and screen voltages. Grid-bias values are not particularly critical, and correct circuit adjustment may be obtained with widely different values.

When a preceding stage is keyed, sufficient fixed bias should be used to maintain the plate current at a low value when the key is up. The screen voltage should be obtained from a fixed low-voltage source if the 814 or a preceding stage is keyed. The regulation of this source need be only good enough to prevent the screen voltage, under key-up conditions from rising higher than twice the maximum screen-voltage rating.

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GENERAL ELECTRIC

Transmitting Tube GL-829 - - Installation and Operation

Installation

The 829 may be mounted by means of a special socket having floating contacts, such as the Type UT-106. The plate terminals take clips with flexible leads. Flexible leads are necessary so that normal expansion will not place a strain on the glass at the seals. Each lead should be connected to its clip before the clip is placed on the plate terminal. Connections should never be soldered directly to the tube terminals because the heat of the soldering operation may crack the lead seals. The 829 may be mounted in a vertical position with the plate terminals either up or down. It may also be mounted in a horizontal position provided the plane of each plate is vertical (on edge).

The bulb becomes very hot during continuous operation of the tube so that forced air cooling is recommended.

The heaters of the 829 are connected in series within the tube. The center connection is brought out of the bulb to a separate pin terminal to permit either series operation from a 12.6-volt supply or parallel operation from a 6.3-volt supply. Either an a-c or a d-c supply may be used. Under any condition of operation, the heater-voltage should not deviate more than plus or minus 5 per cent from the rated value.

The cathodes of the 829 are connected together within the tube. The cathode circuit should be connected to the electrical midpoint of the heater circuit when the heaters are operated from an a-c supply, or to the negative heater-supply lead when the heaters are operated from a d-c source. In circuits where the cathode is not directly connected to the heater, the potential difference between them should not exceed 100 volts. If the use of a large resistor is necessary between heater and cathode in some circuits, it should be bypassed to avoid the possibility of hum.

The plates of the 829 show no color when the tube is operated at its maximum plate-dissipation rating.

The screens of the 829 are connected together within the tube, and they are bypassed by means of a 65 μμf condenser connected inside the tube between the screens and cathodes. Screen voltage may be obtained from a separate source, from a voltage divider, or from the plate supply through a series resistor. The choice of method depends on the service in which the tube is used (see OPERATION). When the screen voltage is obtained from a separate source, or from a voltage divider, plate voltage should be applied before or with the screen voltage. Otherwise, with voltage on the screens only, the screen current may rise high enough to cause excessive screen dissipation. When screen-voltage regulation is not an important factor, the series resistance method for obtaining screen voltage is desirable because of its simplicity and because it limits the d-c power input to the screen. A d-c milliammeter should be used in the screen circuit so that the screen current can be measured and the d-c power input to the screen determined. The screens should not be allowed to attain a temperature corresponding to more than a barely perceptible red color. This temperature corresponds to the screen-input values shown under TECHNICAL INFORMATION.

It is, perhaps, not too well known that the screen current is a very sensitive indication of plate-circuit loading and that screen current rises excessively (often to the point of damaging the tube) when the amplifier is operated without a load. Therefore, care should be taken when tuning an 829 under no-load conditions in order to prevent exceeding the screen-input rating of the tube.

A protective device, such as a high-voltage fuse, should be used to protect both the screens and plates against overloads. When a bleeder resistor of poor regulation or a series resistor is used for obtaining the screen voltage, this device should be placed in the common positive high-voltage supply lead. It should remove the high-voltage supply when the d-c plate current reaches a value 50 per cent greater than normal. When the screen voltage is obtained from a separate source or from a voltage divider of good regulation, a protective device should also be

placed in the screen-supply lead. It should remove the screen voltage when the d-c screen current reaches a value of 50 per cent greater than normal.

Shielding of the r-f amplifier stage employing the 829 is required for stable operation. A convenient method of shielding is to insert the plate end of the tube through a hole in a metal plate so that the edge of the opening is in close proximity to the internal shield of the tube. An alternative shielding and mounting arrangement is to insert the grid end of the tube through a hole in the shield and then clamp a ring or cup to the chassis so as to complete the shielding and lock the tube in the mounting.

R-f by-passing of the 829 at its terminals is necessary in order to realize the full capabilities of the tube at the ultra-high frequencies. Conventional by-passing methods and grounding are not adequate. One convenient method of by-passing is to use ribbon heater and screen leads to the tube terminals and to insulate the leads from the external shield plate by means of mica spacers to form by-pass condensers right at the tube terminals. It is important that the grid-, plate-, and screen-circuit returns are made to the common cathode connection in order to avoid r-f interaction through common return circuits. It may also be advisable in some applications to supplement the action of the by-pass condensers by r-f chokes placed close to the condensers in the voltage supply leads.

In order that the maximum ratings are not exceeded, changes in electrode voltages due to battery- or line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus must be determined. An average value of voltage for each electrode should then be determined. An average value of voltage for each electrode should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate and screen voltage. This may be done conveniently by means of a protective resistance of about 2000 ohms (total) in series with the screen lead and a protective resistance of about 2000 ohms in series with the high-voltage supply lead.

Operation

In grid-modulated Class C telephone service, the 829 is supplied with unmodulated r-f grid excitation voltage and with a d-c grid bias which is modulated at audio frequencies. Grid bias should preferably be obtained from an un-by-passed cathode resistor, although it may also be obtained from a fixed supply or a grid leak. The plates are supplied with unmodulated d-c voltage. The audio power required in this service is very small and need be sufficient only to meet the peak power requirement of the grids of the Class C amplifier on the positive crest of the input signal. The actual peak value is generally never more than 0.15 watt. The screen voltage should be obtained from a separate source or from a voltage divider connected across the plate supply.

In plate-modulated Class C r-f amplifier service, GL-829 can be modulated 100 per cent. The screen voltage should preferably be obtained from a voltage-dropping resistor in series with the modulated plate supply, although it may also be obtained from a fixed supply. In any case, the screen voltage must be modulated simultaneously with the plate voltage so that the ratio of screen voltage to plate voltage remains constant. Modulation of a fixed screen-voltage supply can be accomplished either by connecting the screen lead to a separate winding on the modulation transformer or by connecting it through a blocking condenser to a tap on the modulation transformer or choke. With the latter method, an a-f choke of suitable impedance for low audio frequencies should be connected in series with the screen-supply lead. Control-grid bias should be obtained from a grid leak or from a combination of either grid leak and fixed supply, or grid leak and cathode-bias resistor. The combination method of grid leak and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion effects by bias-supply compensation. Grid-bias voltage for Class C service is not particularly critical so that correct adjustment may be obtained with values differing widely from those indicated for this service.

In Class C r-f telegraph service, the 829 may be supplied with screen voltage by any of the methods shown under INSTALLATION. When a series screen resistor is used, the regulation of the plate supply should be good enough so that the plate voltage will not exceed 600 volts under key-up conditions. Grid bias may be obtained by any convenient method.

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Transmitting Tube GL-833-A - - Installation and Operation

Installation

Terminal connections for the 833-A can be conveniently made with the special connectors, collectively identified as Type UT-103. The UT-103 consists of one polarized mounting, Type MI-7477, for the filament, and two connectors, Type MI-7478, for the grid and plate. One filament post of the 833-A is faced and permits only one-way insertion of the tube in the polarized mounting. This prevents accidental reversal of the grid and plate terminals. The 833-A may be operated in either a vertical or a horizontal position. When the tube is operated in a horizontal position, it should be mounted with the plate in a vertical plane (on edge). When the tube is subjected to vibration or shock, a shock-absorbing suspension must be used. The filament posts should make firm large-surface contact with their terminals to prevent heating by the filament current. Heavy, well-soldered leads should be used for the filament-circuit wiring.

Connections to the grid and plate terminals must be flexible enough so that they will not place a strain on the glass at the seals, yet heavy enough to carry the high circulating r-f current which flows at the very high frequencies. The connections should be fastened to the nickeled section of the terminal posts and not to the post shoulders. Special grid- and plate-post connectors, such as the Type MI-7478, should be used when the tube is operated at frequencies above 15 megacycles. The connectors aid in cooling the terminal posts and their seals. The leads should be fastened to the connectors before they are placed on the terminal posts. If the leads are soldered to the connectors, a hard type of solder should be used. This solder should remain firm at temperatures of 250 C or more. Never solder directly to the terminal posts as the heat of soldering may result in cracking of the seals. The grid- and plate-terminal posts should not be used to support coils, condensers, or other circuit parts.

Cooling requirements for the 833-A depend on the plate voltage and plate input for each class of service as indicated under MAXIMUM RATINGS. When the operating conditions do not require forced-air cooling, provision should be made for adequate free circulation of air around the tube. When the operating conditions are such as to require forced-air cooling (as shown in tabulated ratings), an air flow of 40 cubic feet per minute is required. The stream of air should be directed vertically downward on the top of the bulb (between the grid seal and the plate seal) by a nozzle having a diameter of about 2 inches. With forced-air cooling, the temperature of the bulb surface between the grid seal and the plate seal must not exceed 145 C. Care should be taken that the bulb does not come in contact with any metallic object. The installation of all wires and connections should be made so that they will not be close to or touch the bulb. This precaution is necessary to avoid puncture of the bulb due to peak voltage effects.

The filament of the 833-A is of the thoriated-tungsten type. It may be operated either from an a-c or a d-c supply. A voltmeter should be permanently connected across the filament terminals to provide a ready check of the filament voltage. This voltage should not vary more than ±5 per cent from the rated value; otherwise, a loss of emission may result. The filament should be operated at eighty per cent of normal filament voltage during stand-by periods of less than two hours and shut down entirely for longer periods. The circuit returns should be made to the negative filament terminal when a d-c supply is used, and to the center tap of the filament-transformer secondary when an a-c supply is used. The 833-A filament should be operated at constant voltage rather than constant current and must be allowed to reach normal operating temperature before other voltages are applied. Since the filament current of the tube is very high, the filament connectors should be large and make good contact.

The plate of the 833-A shows an orange-red color at the maximum plate-dissipation rating for each class of service.

Overheating of the 833-A by severe overload may decrease the filament emission. Filament activity can sometimes be restored by operating the filament at rated voltage for ten minutes or more with no voltage on the grid or plate. This process may be accelerated by raising the filament voltage to 12 volts (not higher) for a few minutes. In order to prevent overheating due to improper circuit adjustment, to overloading, or to loss of grid bias, the positive plate-supply lead should be provided with a protective device, such as a high-voltage fuse or an overload relay. This device should instantly remove the plate voltage when the d-c plate current reaches a value 50 per cent greater than normal. In audio-frequency service, a spark gap with 3/32 inch spacing may be connected between the grid and one side of the filament to protect the tube against damage caused by excessive peak voltage.

In order that the maximum ratings given under CHARACTERISTICS will not be exceeded, changes in plate and filament voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated equipment must be determined. An average value of plate and filament voltage should then be chosen so that under the usual line-voltage variations the maximum rated voltage will not be exceeded.

WHEN A NEW CIRCUIT IS TRIED OR WHEN ADJUSTMENTS ARE MADE, THE PLATE VOLTAGE SHOULD BE REDUCED IN ORDER TO PREVENT DAMAGE TO THE TUBE OR ASSOCIATED APPARATUS IN CASE THE CIRCUIT ADJUSTMENTS ARE INCORRECT. IT IS ADVISABLE TO USE A PROTECTIVE RESISTANCE OF ABOUT 6500 OHMS IN SERIES WITH THE HIGH VOLTAGE LEAD DURING SUCH ADJUSTMENTS.

THE RATED PLATE VOLTAGE OF THIS TUBE IS HIGH ENOUGH TO BE DANGEROUS TO THE USER CARE SHOULD BE TAKEN DURING THE ADJUSTMENT OF CIRCUITS, ESPECIALLY WHEN THE EXPOSED CIRCUIT PARTS ARE AT HIGH D-C POTENTIAL.

Operation

The maximum plate-voltage values shown under CHARACTERISTICS may be used provided the plate current for each service is limited so that the respective maximum plate-input rating is not exceeded. Likewise, the maximum plate-current values may be used provided the plate voltage for each service is limited so that the respective maximum plate-input rating is not exceeded.

In Class B modulator or a-f service, two 833-A's are used in a balanced circuit, each tube amplifying half the time. The input transformer should be designed to give good frequency response when operated into an open circuit, such as that represented by the grid circuit of the Class B stage when the signal amplitude is small. It should also be designed to handle the required input power for a strong signal. The output transformer should be designed so that the resistance load presented by the modulated Class C amplifier is reflected as the correct plate-to-plate load in the Class B a-f stage. For example, for the 3000-volt condition, a plate-to-plate load of 9500 ohms is required. If an output transformer efficiency of 90 per cent is assumed, two 833-A's operated under conditions shown for a 3000-volt plate supply are capable of modulating 100 per cent an input of approximately 2970 watts to a Class C r-f power amplifier. Since two 833-A's will modulate 2970 watts, a convenient Class C amplifier would be one operating at 6000 volts and 495 milliamperes. These conditions represent a resistance of approximately 12120 ohms. The ratio of the output transformer is then 12120 ÷ 9500, or 1 to 1.13, step-up. The transformer should be designed with a core sufficiently large to avoid saturation effects which would impair the quality of the output. Grid bias should be obtained from a battery or other source of good regulation. It should not be obtained from a high-resistance supply such as a grid resistor, nor from a rectifier, unless the latter has exceptionally good voltage regulation.

In Class B r-f service, the 833-A is supplied with unmodulated d-c plate voltage. The grid is excited by r-f voltage modulated at audio frequency in one of the preceding stages. Under these conditions, the plate dissipation is greatest when the carrier is unmodulated. Grid bias may be obtained from a battery, from a rectifier of good regulation, or from a cathode resistor, suitably by-passed for both audio and radio frequencies.

In plate-modulated Class C r-f service, the 833-A may be supplied with grid bias from a grid resistor, or from a suit-

able combination of grid resistor and fixed supply or grid resistor and cathode resistor. The cathode resistor should be by-passed for both audio and radio frequencies. The combination method of grid resistor and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also minimizes distortion effects by bias-supply compensation. Grid bias is not particularly critical so that correct adjustment may be obtained with values differing widely from those indicated for this service.

In Class C r-f telegraph service, GL-833-A may be supplied with bias by any convenient method. When the 833-A is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to maintain the plate current at a safe value. With plate voltage of 4000 volts, a fixed bias of at least -90 volts should be used.

If more r-f power output is required than can be obtained from a single 833-A, the push-pull or the parallel connection may be used. For example, two tubes connected in push-pull or parallel will give twice the power output of one tube. The parallel connection requires no increase in exciting voltage; the push-pull connection requires twice the r-f excitation necessary to drive a single tube. With either connection the driving power required is approximately twice that for single-tube operation while the grid bias is the same as that for a single tube. The push-pull arrangement has the advantage of cancelling the even-order harmonics from the output and of simplifying the balancing of high-frequency circuits. The circuits should be arranged to prevent parasitic oscillations so that the tube will not be subjected to excessive voltages and currents.

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Transmitting Tube GL-866-A/866 - - Installation and Operation

The BASE pins of the 866-A/866 fit a standard 4-contact socket. The socket should be installed to hold the tube in a vertical position with the base down. The plate lead is brought out through a separate seal at the top of the bulb.

The CONDENSED-MERCURY TEMPERATURE of the 866-A/866 should be kept within the ranges shown under TECHNICAL INFORMATION. It is recommended that for the most satisfactory operation the condensed-mercury temperature be maintained at 40 ± 5 C. This temperature can be measured with a thermocouple or a small thermometer attached with a minimum amount of putty at a point near the base end of the bulb. Lower than recommended condensed-mercury temperature raises the potential at which the tube starts to conduct and is unfavorable for long filament life. Higher than recommended condensed-mercury temperature decreases the potential at which the tube starts and is favorable for long filament life but reduces the peak inverse voltage which the tube can stand.

The COATED FILAMENT should be operated at the rated value of 2.5 volts under average operating conditions. The filament voltage, measured at the tube terminals, should not vary more than plus or minus 5 per cent from the rated value. This tolerance should include the effects of regulation caused by transmitter-modulation load as well as the normal power-supply regulation. Less than the recommended filament voltage may cause a high voltage drop with consequent bombardment of the filament and eventual loss of emission. Greater than the rated voltage will also shorten the life of the filament.

CAUTION SHOULD BE OBSERVED WHEN THE FILAMENT VOLTAGE IS MEASURED BECAUSE THE FILAMENT CIRCUIT IS AT HIGH D-C POTENTIAL.

The filament of the 866-A/866 should be allowed to come up to operating temperature before the plate voltage is applied. For average conditions, the delay should be approximately 30 seconds. If there is evidence of arcback in the tube, the time delay should be increased. In radio transmitters during "stand-by" periods, the filament should be kept at its rated voltage to avoid delay in "coming back." A protective relay having an obtainable delay period of one minute is desirable in the plate circuit to prevent automatically the application of plate voltage until the filament has reached operating temperature.

When an 866-A/866 is first placed in service, the filament should be operated at normal voltage for approximately 10 minutes without plate voltage in order to distribute the mercury properly. This procedure need not be repeated unless, during subsequent handling, the mercury is spattered on the filament and plate.

The 866-A/866 should be isolated from the transmitter as much as possible in order to avoid the detrimental effects of electromagnetic and electrostatic fields. These fields tend to produce breakdown in mercury vapor, are detrimental to tube life, and make filtering difficult. External shielding should be used when the tubes are in proximity to these fields. R-f filtering should be used when the tubes are affected by r-f voltages. When shields are used, special attention must be given to adequate ventilation and to the maintenance of normal condensed-mercury temperature.

OPERATION

FILTER CIRCUITS of either the condenser-input or the choke-input type may be used. If the condenser-input type of filter is used, special attention must be given to the instantaneous peak value of the a-c input voltage which is about 1.4 times the rms value as measured with an a-c voltmeter. It is important, therefore, that the filter condensers (especially the input condenser) have a sufficiently high breakdown rating to withstand the instantaneous peak value. With the condenser-input type of filter, the peak plate current of the tube is considerably higher than the load current. When choke-input to the filter is used, the peak current is substantially reduced. This type of filter is preferable from the standpoint of obtaining the maximum continuous d-c output current from the 866-A/866 under the most favorable conditions.

Two or more 866-A/866's may be connected in parallel to give a corresponding

increase in output current over a single tube. In this service, a stabilizing resistor of approximately 50 ohms should be connected in series with each plate in order that a proportionate share of the total load current will be carried by each tube. In special cases where it is desirable to minimize the small power loss caused by the voltage drop through the stabilizing resistor, an inductance of approximately one-third henry may be connected in series with the plate lead of each tube in place of the stabilizing resistor. The inductance has the added advantage of limiting the peak current to each tube, which is especially desirable when a condenser-input type of filter is used.

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ELECTRONICS DEPARTMENT
GENERAL ELECTRIC

Forced-air-cooled Transmitting Tubes - - Installation and Operation

INSTALLATION

MECHANICAL

The handling of a transmitting tube requires care since a tube may be damaged if subjected to shock or vibration.

The tube should be tested upon receipt in the equipment in which it is to be used. The glass bulb, and particularly the glass area around the terminals, should be free from foreign matter The leads become hot during operation so that any foreign material may become charred and cause puncture of the bulb.

The standard mounting supports the tube in the correct vertical position with the glass end up. The tube must not be subjected to vibration or shock. It is advisable to secure the tube in its mounting jacket in the desired location before making the electrical connections. The grid and filament leads should not be taut, but should allow for some movement without placing a strain on the glass bulb. Before readjustment of the tube is made, the leads should be disconnected.

Cooling

The air-cooling system for the anode consists of a blower with a suitable air duct leading to the fin cooler of the tube. The air flow required is specified on the Description and Rating Sheet for each type. The temperature of the incoming air should not exceed 45 C.

Proper cooling must be provided to limit the glass temperature to not more than 150 C at the hottest point. Usually deflecting vanes diverting the outgoing air toward the terminal seals provide sufficient cooling. In some cases it may be necessary to provide a separate cooling system. This system may consist of a blower and an air duct of suitable cross-sectional area leading to a nozzle directing the air flow. For the 893-R a nozzle is incorporated in the cathode base. The air flow required is specified on the Description and Rating Sheet for each type.

The cooling air must not contain any foreign matter. The air-cooling systems should be properly installed to insure safe operation of the tube under all conditions and for this reason should be electrically interconnected with the filament and plate supplies to prevent the application of voltages to the tube without suitable cooling. An air-flow interlock which removes the filament and plate power is necessary to protect the tube when the air flow is insufficient or ceases. Precautions should be taken to insulate the air-cooling system from the anode and grid.

ELECTRICAL

Suitable meters should be provided for reading filament voltage, plate voltage and current, and d-c grid current. A tube life recording meter (to read hours of operation) should also be provided.

The installation of all wires and connections must be made so that they do not lie on or close to the glass of the tube. Otherwise, severe trouble may arise from corona discharge or increased dielectric loss which will result in almost certain puncture.

The filament circuit carries a high current at low voltage. Therefore, precautions should be taken against loss of voltage and heating due to poor connections. The filament connectors particularly should be large and make good contact.

In the case of the 8002-R tube, three filament leads are brought out to terminals. These may be paralleled by capacitors to reduce the inductance of the filament circuit for the r-f returns. The filament sections must be operated in series from the filament supply. The center tap is to be used only for r-f or power supply returns.

The high initial rush of current through the filament when the switch is first closed should be limited by the use of some form of filament starter. This may be a system of time-delay re-

lays cutting resistance out of the circuit, a high-reactance filament transformer, or a manual control. In any case, the starting current must never, even momentarily, exceed 1 1/2 times the normal value. Provision must be made also for accurate adjustment and maintenance of the filament voltage. The filament voltmeter should be connected to indicate the voltage at the filament terminals. The filament base should not be connected to ground or to any part of the circuit. Filament power may be alternating current or direct current. When alternating current is used, the plate and grid circuit returns should be made to the center point of the filament supply. When direct current is used, these returns should be made to the negative terminal.

For multiphase filament tubes it is essential that the connections for each type of filament voltage supply be made according to the circuit diagram† to prevent distortion and possible failure of the filament.

The plate circuit should be provided with a time-delay relay to delay the application of plate voltage until the filament has reached at least eighty per cent of the normal voltage. It must be provided also with protective devices to prevent the tube from drawing a heavy overload. The coil of an instantaneous overload relay (set for slightly higher than normal plate current) placed in the ground lead of the plate return and operating to remove the plate voltage, may be used for this purpose. The total time required for the operation of the relay and breaker should be in the order of one-tenth second and not more than one-sixth second. Plate series protective resistors should also be provided to protect the tube from excessive energy dissipation during instantaneous failure of insulation, within the tube or within the transmitter. The minimum value of this resistor which will give adequate protection with minimum power loss is given on the Description and Rating Sheet. Precautions must be taken so that no high capacitance is connected directly across the tube in such a manner that a disturbance within the tube will discharge appreciable energy from the capacitor.

The grid circuit should be provided with heavy conductors, carefully connected, in order to prevent overheating of the grid terminal due to r-f currents.

In the 8002-R tube three grid leads are brought out to terminals. These may be used in parallel to reduce the inductance of the grid circuit. If desired, to reduce coupling, one lead may be used for the neutralizing circuit and the other two for the grid-excitation circuit. When the tube is used in an oscillator circuit at the higher frequencies, it may be necessary to neutralize the feedback partially in order to prevent excess grid excitation caused by the normal grid-plate capacitance.

If two or more tubes are used in the circuit, controls should be provided so that adjustment may be made to balance properly the plate current taken by each tube.

In Class B service, grid bias of excellent regulation is usually required.

In Class C service, the bias voltage may be supplied by a grid leak, or by a combination of grid leak and generator, grid leak and rectifier, or grid leak and cathode-bias resistor suitably by-passed. The combination method is particularly suitable to reduce distortion, especially in plate-modulated operation. Since the grid-bias voltage for Class C service is not particularly critical, correct circuit adjustment may be obtained with values differing widely from those indicated for this service.

The circuits should be arranged to prevent parasitic oscillations so that the tube will not be subjected to excessive voltages and currents.

OPERATION

When a new tube is first placed in operation, it should be operated without plate voltage for fifteen minutes at rated filament voltage. After this initial preheating schedule, plate voltage can be applied. Operate for fifteen minutes at approximately one-half the usual plate voltage. Full voltage may then be applied and the tube operated under the normal load conditions for a period of one hour or more. Every three months spare tubes should be given this

† See Description and Rating Sheet.

preheating and initial operation schedule.

The filament should be operated at constant voltage rather than constant current and must be allowed to reach at least eighty per cent normal voltage before plate voltage is applied. Intermittent power supply interruptions may be allowed provided the time off does not exceed one second. If the tube is to be used at relatively low output, the plate current will be less than normal, requiring less than normal emission of the filament. The filament, therefore, may be operated at a voltage slightly lower than rated voltage, giving longer life. The permissible reduction in filament voltage may be checked by reducing the filament voltage with the transmitter under normal operation to a value where reduction in output or increase in distortion can just be detected. The filament voltage must then be increased by an amount equivalent to the maximum percentage regulation of the filament supply voltage. Care must be taken that sufficient emission is provided. Otherwise, instability of operation or excessive distortion may be experienced, or the rated plate dissipation of the tube may be exceeded. From the viewpoint of tube life, it is usually economically advantageous to provide good regulation of the filament voltage. For example, if the filament is operated continuously at six per cent above normal voltage, the evaporation life will be reduced to approximately one half.

When a multiphase filament-supply voltage is used, the phase voltages must all balance within fifteen per cent during the filament starting period. During normal operation the phase voltages must never, even momentarily, exceed ten per cent unbalance.

If the apparatus in which the tube is used is to be idle for periods not exceeding two hours, voltage should be maintained on the filament. However, if desired, provision may be made to reduce the filament voltage to approximately eighty per cent of the rated value during the stand-by. Where stand-by periods exceed two hours the filament voltage may be removed.

When direct-current filament excitation is used, the filament leads should be reversed every five hundred hours of operation.

Maximum ratings and typical operating conditions for each recommended class of service are given on the Description and Rating Sheet. The amplifier classifications used are those given in the Report of the Standards Committee of the Institute of Radio Engineers.

The output values given in the tabulation on the Description and Rating Sheet are approximate tube outputs under certain typical operating conditions. These must not be used as output ratings; circuit losses must be subtracted from the tube output in calculating the useful output.

In determining the value of plate voltage for normal operation, the line voltage fluctuation, load variation, and manufacturing variations must be estimated so that the maximum rated values will not be exceeded.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced to approximately one-half the rated value to prevent damage to the tube or associated apparatus. After correct adjustment has been made with the tube operating smoothly and without excessive heating of the cooler or the glass bulb, the plate voltage may be raised in several steps to the desired value. Adjustments should be made at each step for optimum operation.

In case of overload and resultant overheating of the tube, the vacuum may be impaired. When the quantity of gas is not too great, the tube may be operated to bring about an electrical clean-up of the gas. The first step in the process should be a short period of operation at a plate voltage of one-half the normal value. The plate voltage should then be increased to the normal value and the tube allowed to operate for a period of one hour or more. In severe cases it may be possible to age the tube by operating with a series resistor in the plate supply. Short periods of operation may be conducted at each step as the resistor is reduced until stable operation at the normal plate voltage is obtained.

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GENERAL ELECTRIC

Transmitting Tube GL-836 - - Installation and Operation

Installation

The base of the GL-836 fits the standard 4-contact socket such as the Type UR-542A. The socket may be mounted to hold the tube in any position.

The bulb becomes very hot during continuous operation. Provision should be made for adequate natural ventilation to prevent overheating.

The heater of the 836 is designed for a-c operation from a secondary winding of a power transformer. The winding should supply at the socket terminals the rated voltage of 2.5 volts under average operating conditions. The heater voltage measured at the tube terminals should not vary more than ±5 per cent from the rated value. This tolerance should include the effects of regulation caused by transmitter-modulation load as well as the normal power-supply regulation. Voltage should be applied to the heater for a length of time sufficient to permit the cathode to come up to operating temperature before plate current is drawn from the tube. For average conditions, the delay should be approximately 40 seconds. In radio transmitters during stand-by periods, the heater should be kept at its rated voltage to avoid delay in "coming back." If the stand-by periods exceed two hours, the filament current may be shut off. A voltmeter should be connected across the heater circuit at the socket terminals to provide a ready check of the heater voltage. Caution should be observed when the heater voltage is measured because the heater circuit is at high potential.

The cathode of the 836 is connected within the tube to one side of the heater. The positive return lead to the filter and load circuit should be connected to the heater lead (pin 4) to which the cathode is connected. When the heaters of two or more 836's are operated in parallel, the corresponding cathode leads must be connected together; likewise, the corresponding heater leads.

Operation

In full-wave single-phase circuits, two 836's are required to rectify both halves of the a-c voltage. The a-c input voltage (rms) for two tubes, plate-to-plate, must not exceed 3530 volts in order to limit the maximum peak inverse voltage to the rated value of 5000 volts. With a sine-wave input and the use of a suitable choke preceding any condenser in the filter circuit, the no-load d-c output voltage from the rectifier is 0.9 of the a-c input voltage per tube. On this basis, the maximum d-c output voltage is 1590 volts when the maximum a-c input voltage of 1765 volts is used. Under the above voltage and filter conditions, the regulation produced by the drop in the tube at full-load current will not be greater than 55 volts, approximately. The drop due to the transformer and to the filter can be calculated from the d-c resistance of each device.

Filter circuits of the condenser- or the choke-input type may be employed. Where condenser input is used, the capacity of the input condenser must be low enough to limit the peak plate current to rating of the tube. When choke input to the filter is used, the peak plate current is substantially reduced. The choke-input type of filter is preferable from the standpoint of obtaining the maximum continuous d-c output current from the 836 under the most favorable conditions.

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GENERAL ELECTRIC

Transmitting Tube GL-815 - - Installation and Operation

Installation

The base of the GL-815 fits the standard octal socket which may be installed to hold the tube in a vertical position with the base either up or down. It may also be mounted in a horizontal position provided the plane of each plate is vertical (on edge).

The bulb becomes very hot during continuous operation of the tube so that free circulation of air around the tube should be provided.

The heaters of the 815 are connected in series within the tube with a center tap brought out to a separate base pin. This arrangement permits either series operation from a 12.6-volt supply or parallel operation from a 6.3-volt supply. Either an a-c or d-c supply may be used. Under any condition of operation, the heater voltage should not vary more than ±10 per cent from the rated value. The heaters should be operated at normal voltage during stand-by periods. If the stand-by periods exceed two hours, the filament current may be shut off.

The cathodes of the 815 are connected together within the tube. The cathode circuit should be connected to the electrical midpoint of the heater circuit when the heaters are operated from an a-c supply, or to the negative heater-supply lead when the heaters are operated from a d-c source. In circuits where the cathode is not directly connected to the heater, the potential difference between the heater and cathode should not exceed 100 volts. If the use of a large resistor is necessary between heater and cathode in some circuits, it should be by-passed to avoid the possibility of hum.

The plates of the 815 show no color when the tube is operated at its maximum plate-dissipation rating.

The screens of the 815 are connected together within the tube. Screen voltage may be obtained from a separate source, from a voltage divider, or from the plate supply through a series resistor. The choice of method depends on the service in which the tube is used (see OPERATION). When the screen voltage is obtained from a separate source or from a voltage divider, plate voltage should be applied before or with the screen voltage. Otherwise, with voltage on the screens only, the screen current may rise high enough to cause excessive screen dissipation. When screen-voltage regulation is not an important factor, the series resistance method for obtaining the screen voltage is desirable because of its simplicity and because it limits the d-c power input to the screen. A d-c milliammeter should be used in the screen circuit so that the screen current can be measured and the d-c power input to the screen determined. The screens should not be allowed to attain a temperature at which they will show color.

The screen current is a very sensitive indication of the plate-circuit loading and rises excessively (often to the point of damaging the tube) when the amplifier is operated without load. Therefore, care should be taken when tuning an 815 under no-load conditions in order to prevent exceeding the screen-input rating of the tube.

A protective device, such as a high-voltage fuse, should be used to protect both the screens and the plates against overloads. When a bleeder resistor of poor regulation or a series resistor is used for obtaining the screen voltage, this device should be placed in the common positive high-voltage supply lead. It should remove the screen voltage when the d-c screen current reaches a value 50 per cent greater than normal.

Shielding of the r-f amplifier stages employing the 815 is required for stable operation. A convenient method of shielding is to insert the plate end of the tube through a hole in a metal plate so that the edge of the opening is in close proximity to the internal shield of the tube.

R-f by-passing of the 815 at its socket is necessary in order to realize the full capabilities of the tube at the ultrahigh frequencies. The impedance between the screen and the cathode must be kept low, usually by means of a suitable by-pass condenser. It may also be advisable in some applications to supplement the action of the by-pass condensers by r-f chokes placed close to the condensers in the voltage supply leads. It is important

that the grid-, plate-, and screen-circuit returns are made to the common cathode connection in order to avoid r-f interaction through common circuit returns.

In order that the maximum ratings given under CHARACTERISTICS are not exceeded, changes in electrode voltages due to battery- or line-voltage fluctuations, load variation, and manufacturing variation of the associated apparatus must be determined. An average value of voltage for each electrode should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate and screen voltages. This may be done conveniently by means of a protective resistance of about 4000 ohms (total) in series with the screen lead and a protective resistance of about 2000 ohms in series with the high-voltage supply lead.

The rated plate voltage of this tube is high enough to be dangerous to the user. Care should be taken during the adjustment of circuits, especially when the exposed circuit parts are at high d-c potential.

Operation

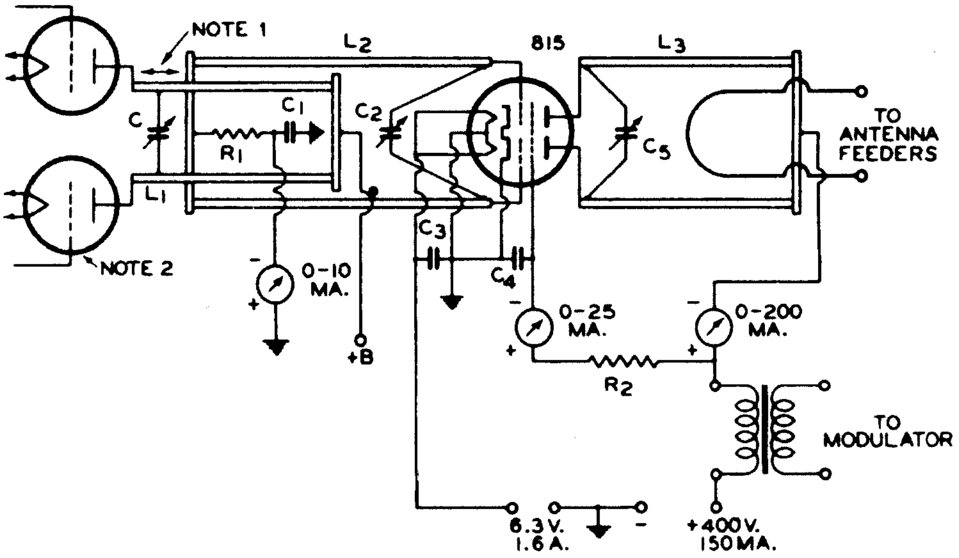
In Class AB_2 audio service, the 815 may be operated as shown under CHARACTERISTICS. The values cover operation with fixed bias and have been determined on the basis of some grid-current flow during the most positive swing of the input signal.

In Class B r-f service, the 815 is supplied with unmodulated d-c plate voltage and the grid is excited with r-f voltage modulated at audio frequency in one of the preceding stages. Under these conditions, the plate dissipation is greatest when the carrier is unmodulated. The screen voltage should be obtained from a separate source or from a voltage divider connected across the plate-voltage supply. Grid bias may be obtained from a rectifier of good regulation, or from a cathode resistor suitably by-passed for both audio and radio frequencies.

In grid-modulated Class C r-f service, the 815 is supplied with unmodulated r-f excitation voltage and a d-c grid bias which is modulated at audio frequencies. Grid bias should preferably be obtained from a fixed supply. The plates are supplied with unmodulated d-c voltage. The audio power required in this service is very small and need be sufficient only to meet the peak power requirement of the grids of the Class C amplifier on the positive crest of the input signal. The actual peak value is generally never more than 0.5 watt. The screen voltage should be obtained from a separate source or from a voltage divider connected across the plate supply.

In plate-modulated Class C r-f amplifier service, the GL-815 can be modulated 100 per cent. The screen voltage should preferably be obtained from a voltage-dropping resistor in series with the modulated plate supply, although it may also be obtained from a fixed supply. In any case, the screen voltage must be modulated simultaneously with the plate voltage so that the ratio of screen voltage to plate voltage remains constant. Modulation of a fixed supply can be accomplished either by connecting the screen lead to a separate winding on the modulation transformer or by connecting it through a blocking condenser to a tap on the modulation transformer or choke. With the latter method, an a-f choke of suitable impedance for low audio frequencies should be connected in series with the screen-supply lead. Control-grid bias should be obtained from a grid resistor or from a combination of grid resistor and fixed supply, or grid resistor and cathode resistor. The combination method of grid resistor and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation. Grid-bias voltage for Class C service is not particularly critical so that correct adjustment may be obtained with values differing widely from those indicated for this service.

In Class C r-f telegraph service, the 815 may be supplied with screen voltage by any of the methods shown under INSTALLATION. When a series screen resistor is used, the regulation of the plate supply should be good enough so that the plate voltage will not exceed 600 volts under key-up conditions. Grid bias may be obtained by any convenient method.



C = See L_1

C_1 C_3 C_4 = 1 in. x 1 1/2 in. copper sheet insulated from chassis by mica sheet 0.002 in. thick, or 0.0005-μf "postage stamp" mica condensers soldered to chassis with shortest practicable leads.

C_2 C_5 = Copper disks, 1/16 in. x 1 1/2 in. Solder disks to 10-32 brass screws 1 in. long. Drill and tap grid and plate lines for 10-32 screws.

R_1 = 15,000 ohms, 0.5 watt

R_2 = 15,000 ohms, 25 watts, adjustable

L_1 = 1/2 in. diameter copper tubing. Length of tubing and capacitance of C depend upon driver tubes employed.

L_2 = 1/2 in. diameter copper tubing, 12 1/2 in. long and spaced approximately 7/8 in. between centers.

L_3 = 1/2 in. diameter copper tubing, 13 in. long and spaced approximately 7/8 in. between centers.

NOTES

(1) The r-f driver stage should be able to deliver about one watt of useful r-f power, in order to insure ample grid excitation for the 815.

(2) Adjust coupling between L_1 and L_2 and tuning of C and C_2 for recommended d-c grid current of the 815.

(3) L_1 and L_2 should be effectively shielded from L_3 by a metal chassis, or by a vertical metal baffle plate used to mount the 815.

(4) Adjust coupling of "hairpin" antenna coil to L_3 so that the amplifier is properly loaded.

(5) A small lumped inductance can be substituted for the amplifier grid lines, if desired. Such a grid coil is preferably tuned by varying its inductance, rather than by means of a variable condenser.

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GENERAL ELECTRIC

Transmitting Tube GL-1616 -- Installation and Operation

Installation

The base of the 1616 fits the standard 4-contact socket such as the Type UR-542A. The plate connection is made to the cap at the top of the bulb.

The coated filament should be operated at the rated voltage of 2.5 volts under average operating conditions. The filament voltage, measured at the tube terminals, should not vary more than plus or minus 5 per cent from the rated value. This should include the effects of regulation caused by the varying load as well as the normal power-supply regulation. Less than the recommended voltage will increase the voltage drop and the plate dissipation. Greater than the rated voltage will shorten the life of the filament.

The filament and plate voltage of the 1616 may be applied simultaneously under full load conditions. However, in applications where rapid off-on operation is necessary, the filament should be kept at its rated voltage.

Caution should be observed when the filament voltage is measured because the filament circuit is a high d-c potential.

Operation

The maximum surge-current rating is a measure of the ability of a tube to withstand extremely high transient currents of short duration. This rating is intended for use only in the design of equipment as an allowable limit for abnormal currents during switching operations which occur, for example, when the tube works into a low-impedance filter such as an uncharged filter condenser.

In full-wave, single-phase rectifier circuits, the a-c input voltage (rms) for two 1616's, plate-to-plate, must not exceed 3900 volts in order to limit the maximum peak inverse plate voltage to the rated value of 5500 volts. With a sine-wave input and the use of a suitable choke preceding any condenser in the filter circuit, the no-load d-c output voltage is 0.9 of the a-c input voltage per tube. On this basis the maximum d-c output is 1750 volts when the maximum a-c input voltage per tube is 1950 volts. Under the above voltage and filter conditions the regulation produced by the drop in the tube at full-load current will not be greater than 90 volts approximately. The drop due to the transformer and to the filter can be calculated from the d-c resistance of each device.

Filter circuits of either the condenser-input or the choke-input type may be employed. Where condenser input is used the capacity of the input condenser must be low enough to limit the peak and surge currents to the rating of the tube. When choke input to the filter is used the peak and surge currents are substantially reduced. The choke-input type of filter circuit is preferable from the standpoint of obtaining the maximum continuous d-c output current from the 1616 under the most favorable conditions.

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GENERAL ELECTRIC

Transmitting Tube GL-8010A-R - - Installation and Operation

MECHANICAL

Mountings must be of good quality and should be so installed as to minimize danger from impact. If the set is subject to vibration, a shock absorbing suspension must be employed. A rigid mounting may be used for one of the three disks; connections to the other two disks must have sufficient flexibility to permit expansion of the glass. All connections should be silver-plated and should be kept clean.

COOLING

The bulb becomes very hot during operation and, therefore, should neither come in contact with any metallic object nor be subjected to drops or spray of liquid.

A small blower is required for cooling the anode end which is fitted with a disk type cooler. Suitable ducts or deflecting vanes should be arranged to direct air across the coolers. Air flow must be sufficient to limit the glass temperature to 100 C at the hottest point. Ordinarily a single blower, giving a static pressure of 1/2 inch of water and the free air delivery of 60 cfm, will suffice for a pair of tubes operating at maximum rating.

ELECTRICAL

The heater supply voltage variation should be less than plus or minus 5 per cent. A voltmeter should be connected to indicate filament voltage at the heater terminals.

The heater connectors should be so designed as to provide positive contact with the heater terminals without placing any strain on the glass bead.

The grid-circuit and plate-circuit return leads should be connected to the cathode.

An ammeter should be connected in the plate circuit of each tube, or pair of tubes in push-pull, so that the direct plate current may be checked regularly. The plate circuit should be provided with a protective device, such as a fuse or relay, in order to prevent overheating caused by improper circuit adjustments or overloading. This device should remove high voltage instantly if the direct current reaches a value 50 per cent above normal. A suitable time delay device should be provided to prevent application of plate voltage for at least one minute after heater voltage has been applied. Plate voltage must be removed immediately whenever heater voltage is removed.

In rating pliotrons, certain values are given as maximum; that is, the values beyond which it is unsafe to go from the viewpoint of life and performance. In order not to exceed the maximum ratings, changes in plate and

filament voltage caused by line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus must be determined. Then, an average value of plate voltage should be chosen so that under the usual operating conditions the maximum ratings will not be exceeded.

IN TRYING OUT A NEW CIRCUIT OR WHEN ADJUSTMENTS ARE MADE, THE PLATE VOLTAGE SHOULD BE REDUCED IN ORDER TO PREVENT DAMAGE TO THE PLIOTRON OR ASSOCIATED APPARATUS IN CASE THE ADJUSTMENTS ARE INCORRECT.

Operation

CLASS C R-F AMPLIFIER

Maximum ratings for this tube are given on the Description and Rating Sheet.

Grid bias for Class C service may be obtained from a grid leak, from a battery, from a rectifier of good regulation, or from a self-biasing resistor by-passed with a suitable capacitor. With the grid-leak method the grid excitation must not be removed without also removing the plate voltage. Grid bias values are not particularly critical, and correct circuit adjustment may be obtained with widely different values.

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GENERAL ELECTRIC

Transmitting Tube GL-8020 - - Installation and Operation

Installation

MECHANICAL

Mountings must be of good quality and should be so installed as to minimize danger from impact. If the set is subject to vibration, a shock-absorbing suspension must be employed.

COOLING

All apparatus must be arranged to allow free circulation of air around the tube. The bulb becomes very hot during operation and, therefore, should neither come in contact with any metallic object nor be subjected to drops or spray of liquid.

Sets using more than one tube should provide adequate spacing between tubes so that adjacent portions of the bulbs do not operate appreciably hotter than the other sections.

Any accumulation of dust and metallic particles on the outer surface of the glass walls will increase the leakage over this surface. As this may result in tube failure from arc-over, periodic cleaning of these surfaces should be maintained.

ELECTRICAL

To avoid danger of corona discharge, all wires and connections should be made to allow several inches of free space around the tube.

The filament should be operated preferably from an a-c source, although a d-c supply may be used. The filament voltmeter should be connected to indicate the voltage at the filament terminals. The filament supply should be designed to allow operation at rated filament voltage. The filament voltage should not vary more than ±5 per cent from the rated value. The filament transformer shall have good regulation and should be designed for at least 30 per cent above rated filament wattage.

When the tube is used in intermittent service the filament voltage may be removed for stand-by periods greater than 15 minutes. There should be no reduction of filament voltage for periods of less than five minutes. The filament voltage may be reduced to 80 per cent during periods greater than five minutes if desired.

Overheating by severe overload may decrease filament emission. Unless the overload has liberated a large amount of gas, the activity of the filament usually can be restored by operating the filament at rated voltage for ten minutes or more with no voltage on the plate or grid. This process may be accelerated by increasing the filament voltage to 20 per cent above the normal value (not higher) for a few minutes.

The plate circuit should be provided with a protective device such as a fuse or relay in order to prevent overheating. This device should remove the plate voltage instantly if the direct-plate current reaches a value 50 per cent above normal.

In the ratings, certain values are given as maximum; that is, the values beyond which it is unsafe to go from the viewpoint of life and performance. In order not to exceed the maximum ratings, changes in plate and filament voltage caused by line-voltage fluctuations, load variation, and manufacturing variation of the associated apparatus must be determined. Then, an average value of plate voltage should be chosen so that under usual operating conditions the maximum ratings will not be exceeded.

Operation

The GL-451 may be used in any of the usual rectifier circuits. Tubes may be operated in parallel to develop the required output current. The ratings given on the Technical Information prescribe two limiting operating conditions.

The first is a maximum peak inverse voltage which should not exceed a certain safe value determined by the insulation between electrodes of the tube. The maximum peak inverse voltage is the highest voltage that the tube will insulate on the half cycle when no current is passing through the tube. As any and all of the following factors - line surges, circuit capacitance, wave form distortion, and the maximum peak voltage of the applied alternating voltage - may increase this inverse voltage to a value higher than the rated maximum peak voltage, the tube should never be used at the maximum rated voltages unless measurements, either by oscillograph or sphere gap, have indicated that at no time does the peak voltage across the tube exceed this value.

The second limiting value is the power dissipation of the plate which is determined by the d-c load current almost regardless of the voltage across the load. The maximum peak plate current is the greatest instantaneous current that may be drawn on the half cycle during which the plate of the tube is positive. As the design of the circuit, especially the amount of capacitance in the circuit, is a major factor in determining the amount of current available in a given rectifier, oscillograph measurements of this current should be made if any doubt exists as to the magnitude.

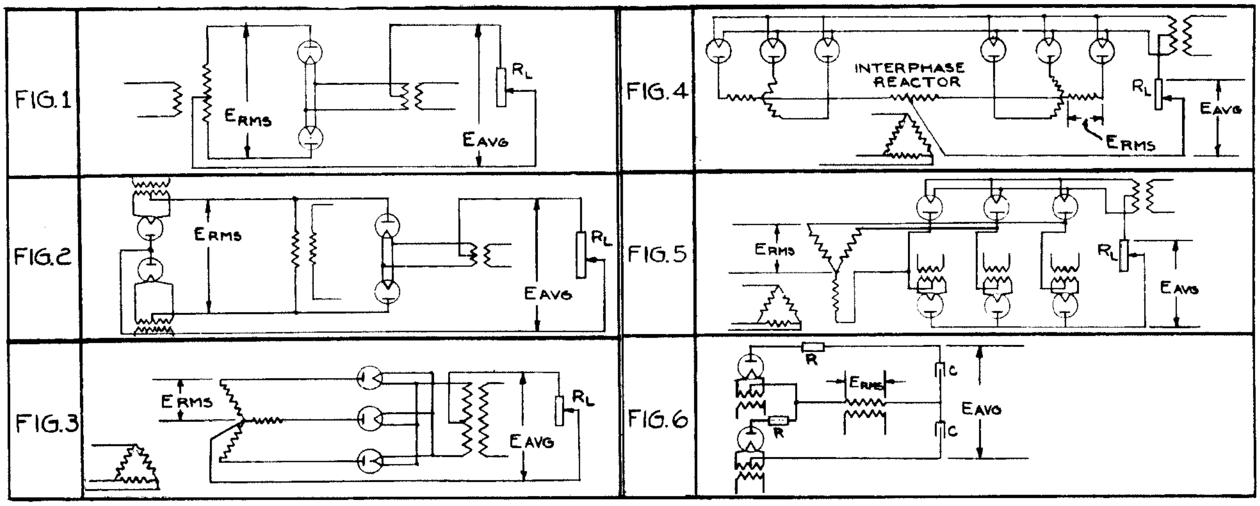

Fig	Circuit	E average	E inverse	I average
1	Single-phase, Full-wave	0.318 Emax 0.450 Erms	Emax 3.14 Eavg	0.636 Imax
2	Single-phase, Full-wave	0.636 Emax 0.900 Erms	Emax 1.57 Eavg	0.636 Imax
3	Three-phase, Half-wave	0.827 Emax 1.170 Erms	$\sqrt{3}$ Emax 2.09 Eavg	0.827 Imax
4	Three-phase, Double-Y Parallel	0.827 Emax 1.170 Erms	1.732 Emax 2.09 Eavg	1.91 Imax
5	Three-phase, Full-wave	1.65 Emax 2.34 Erms	$\sqrt{3}$ Emax 1.05 Eavg	0.955 Imax
6	Voltage Doubler	2.83 Erms No Load Conditions	Eavg No Load Conditions	

Note for Fig 6:

Output voltage depends on load and circuit regulation. The circuit must be designed so that the tube ratings are not exceeded. Particularly, values of C and R must be chosen to limit charging current so that peak current rating of tube will not be exceeded.

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

3-42 (2M)
Filing No. B8850

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GENERAL ELECTRIC

Transmitting Tube GL-8012 -- Installation and Operation

INSTALLATION

Terminal connections for the 8012 can be made conveniently by means of supporting clamps. The clamps should have large contact surfaces but should be of small size in order to minimize circuit capacitances. The filament terminals are brought out through a separate seal at one end of the bulb. The 8012 should be installed to operate in a vertical position.

Connections to the grid and plate terminals must be flexible enough so that normal expansion will not place a strain on the glass at the seals, yet heavy enough to carry the high circulating r-f current. The terminal clamps should be fastened to the grid and plate lead connections before the tube is mounted in position. Clamps should be sprung slightly so that they can be slipped easily over their respective terminals. Connections should never be soldered directly to the tube terminals because the heat of the soldering operation may result in cracking of the lead seals. The tube terminal tips should not be used to support circuit parts unless such parts are extremely light and impose no strains on the tube terminals.

The bulb becomes very hot during continuous operation of the tube so that free circulation of air around the tube should be provided. The installation of all wires and connections should be made so that they will not be close to or touch the bulb, in order to avoid puncture of the glass due to peak voltage effects.

The filament voltage should not vary more than ±5 per cent from the rated value; otherwise a loss of emission may result. It is recommended that, in intermittent operation where the average number of transmissions is greater than 100 per day, the filament be maintained at 80 per cent of normal voltage during stand-by periods. If the number of transmissions is less than 100 per day, the filament power may be either removed or maintained, whichever is preferred. However, in such applications as amateur service where the average number of transmissions is usually not greater than 100 and where the stand-by periods are usually no longer than the transmission periods, the filament voltage may be maintained at normal value during stand-by periods. The filament should be operated at constant voltage rather than constant current.

Overheating of the 8012 by severe overload may decrease the filament emission. The filament activity can sometimes be restored by operating the filament at rated voltage for ten minutes or more with no voltage on plate or grid. This process may be accelerated by raising the filament voltage to 7.5 volts (not higher) for a few minutes. The positive high-voltage supply lead should be provided with a protective device, such as a relay. This device should instantly remove the plate voltage when the d-c plate current reaches a value 50 per cent greater than normal.

The plate of the 8012 shows a dull red color at its maximum plate-dissipation rating for each class of service.

R-f by-passing of the grid- and plate-return circuits should be made to the center lead of the filament. It is important that the returns be made to this common connection in order to avoid r-f interaction through common return circuits. In some applications, it may also be advisable to supplement the action of the by-pass condensers by r-f chokes placed close to the condensers in the voltage-supply leads.

In order that the maximum ratings will not be exceeded, changes in plate and filament voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus must be determined. An average value of plate and filament voltages should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

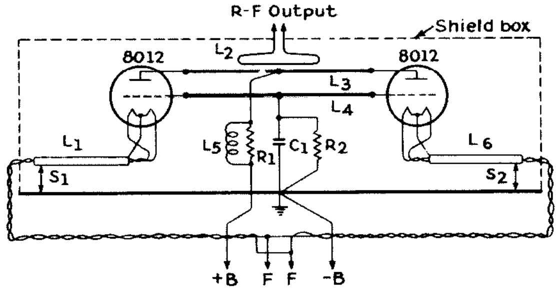
When a new circuit is tried or when adjustments are made, the plate voltage should be reduced in order to prevent damage to the tube of associated apparatus in case circuit adjustments are incorrect. It is advisable to use a protective resistance of about 6000 ohms in series with the plate lead during such adjustments. The rated plate voltage of this tube is high enough to be dangerous to the user. Care should be taken during the adjustment of circuits, especially when the exposed circuit parts are at high d-c plate potential.

OPERATION

In grid-modulated Class C telephone service, the 8012 may be supplied with d-c grid bias from a cathode resistor, unby-passed for audio frequencies, or from a fixed supply. The audio power required in this service is very small. It need be only sufficient to meet the peak power requirement of the grid of the Class C amplifier on the crest of the input signal. The actual peak value is generally never more than three watts.

In plate-modulated Class C r-f service, the 8012 may be supplied with grid bias from a grid resistor, or from a combination of grid resistor with either fixed supply or cathode resistor.

600-Mc PARALLEL-PLATE OSCILLATOR
Useful Power Output, 25 Watts, Approx



C_1 = 0.001 μf mica

L_1 L_6 = Filament Lines: each 5/8" copper tubing, 6 1/2" long, approx.

L_2 = Pickup Loop; 1" high, 2" long, approx.

L_3 = Plate Line: 1/32" sheet copper, 4" by 2 5/16", with cutouts to fit tube bulbs

L_4 = Grid Line: similar to L_3 and spaced approx 3/4" from it.

L_5 = 8 turns of No. 12 copper wire 5/8" diameter wound around R

R_1 = 200 ohms, 2 watts

R_2 = 1200 ohms, 2 watts

S_1 S_2 = Shorting Blocks

Typical Operating Conditions at 600 Mc (both tubes):

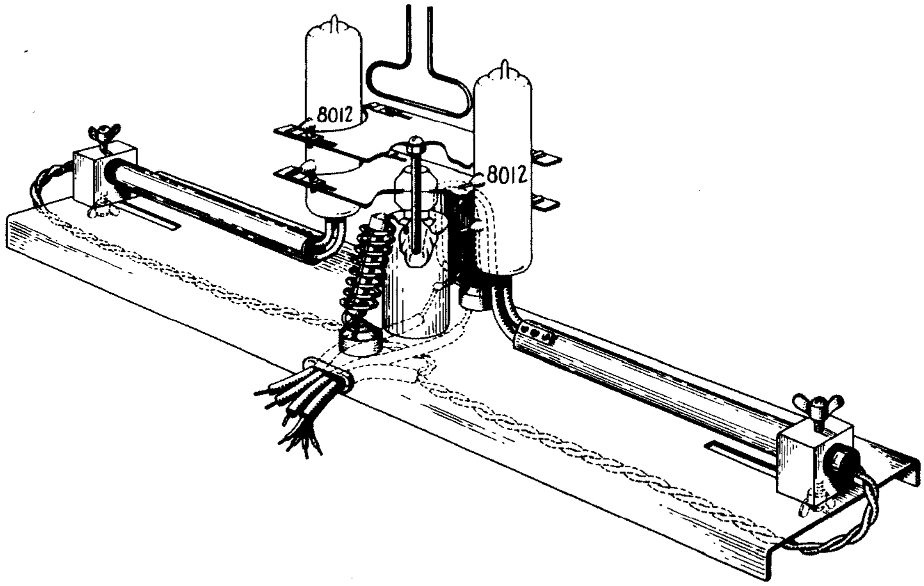
- Filament Voltage = 6.3 volts
- Filament Current = 2 amperes
- Plate Voltage = 450 volts
- Plate Current = 150 Ma, max
- Grid Current = 32 Ma (approx)

The cathode resistor should be suitably by-passed for both a-f and r-f. The combination method has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation.

In Class C r-f telegraph service, the 8012 may be supplied with grid bias by any convenient method. When the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to maintain the plate current at a safe value. If the 8012 is operated at the maximum rated plate voltage of 1000 volts, a fixed bias of at least -40 volts should be used.

When the 8012 is operated at the ultrahigh frequencies, push-pull operation is recommended. This connection has the advantage of simplifying the balancing of high-frequency circuits by providing symmetry of layout. In oscillator service, it is desirable to connect the two grid terminals and the two plate terminals of each tube in parallel in order to reduce their respective lead inductances. A cut-away drawing and a circuit diagram for a 600-Mc oscillator employing two 8012's are shown. This oscillator makes use of two parallel plates, L3 and L4, as frequency-determining elements. Filaments of the tubes are maintained close to ground potential for r-f by means of the tuned filament lines, L1 and L6. The sliding shorting bars, S1 and S2, can be used to control excitation to the grids of the tubes. The slots in L3 and L4 are pri-

marily for mechanical alignment of the tubes, although they can also be used to make minor tuning adjustments. The parallel plates, L3 and L4, are supported at their geometrical centers, and then d-c plate and grid connections are made to the plates at these points. The structural arrangement permits unusual symmetry of construction.



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GENERAL ELECTRIC

Service Sheet for Electronic Tubes

INSTRUCTIONS

Complete instructions are packed with each tube. Additional copies can be secured from the nearest office of the General Electric Company.

General Electric tubes are warranted to be of the kind and quality described in the manufacturers' specifications. Before leaving the factory, each tube is subjected to rigid tests and inspections. Performance will depend, to a large extent, upon the application, and upon the care with which the tubes are handled. In case of doubt as to proper operating conditions, information should be secured from the General Electric Office through which the purchase was made.

INFORMATION AND INSTRUCTIONS

INTRODUCTION

This service sheet is furnished for the convenience of the customer in applying for adjustment if the quality of the tube does not meet the specification and warranty under which the tube was sold. In order that prompt action can be taken the information required in the service report form should be supplied in complete detail.

INITIAL TEST

To assure satisfactory operation, it is recommended that each tube be tested upon receipt by the customer, preferably in equipment of the same type and rating as that in which it is to be used. Such a procedure will assure that tubes damaged in transportation are not carried in stock. If spare tubes are stocked for long periods, a check test should be made at least every three months. The conditions of test and operation shall not be more severe than the conditions described in the manufacturers' specifications and instructions.

TRANSPORTATION CLAIMS

Should the package be received in a damaged condition, observance of the procedure for notifying the Express Company described on the tag affixed to the container will enable the General Electric Company to assist the customer in filing a claim for tubes damaged in transit.

RETURN PROCEDURE

The following procedure should be observed if the tube fails to comply with the specifications or warranty under which it was purchased.

1. The tube should be returned immediately, by prepaid express, to:
   Tube Division
   Electronics Department, Building 269
   General Electric Company
   Schenectady, New York
   Attention: Mr. D. A. Mullaney
2. Notice that a tube in being returned to the factory should be sent to the Service Engineering Division, General Electric Company, Schenectady, New York, giving the date that the tube was originally purchased, original purchase order number (if the tube was furnished on a district office requisition, give the requisition number), and the net purchase price of the tube.
3. Tubes returned for credit adjustment should be packed as carefully as when originally received, for damage sustained in return shipment will make a thorough examination impossible.

If more than one tube is involved, the tubes should be identified by some permanent marking, such as a securely tied tag, which will enable them to be associated with this service report.

PERMISSION FOR DISMANTLING

In returning a vacuum tube for test and examination, the customer gives permission to the General Electric Company to open the tube and to dissect its structure in case such procedure is considered necessary for complete examination.

SERVICE REPORT FORM - NEMA STANDARD

Tube Type No. .... Serial No. ....

Date Received .... Date First Tested ....

Date Placed in Service .... Date Inoperative ....

Hours of Cathode Operation .... Hours of Anode Operation ....

If Stand-by Operation Was Used Show Filament Voltage for Stand-by Condition ....

Nature of Defect ....

....

Describe any unusual phenomena which took place just previous to or at time of failure ....

....

....

Code No. and maker of equipment in which tube was used ....

....

Was tube used in experimental equipment or experimental adjustment ....

....

Were all other circuit elements operating properly at time of tube failure ....

....

Purchaser ....

Address ....

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